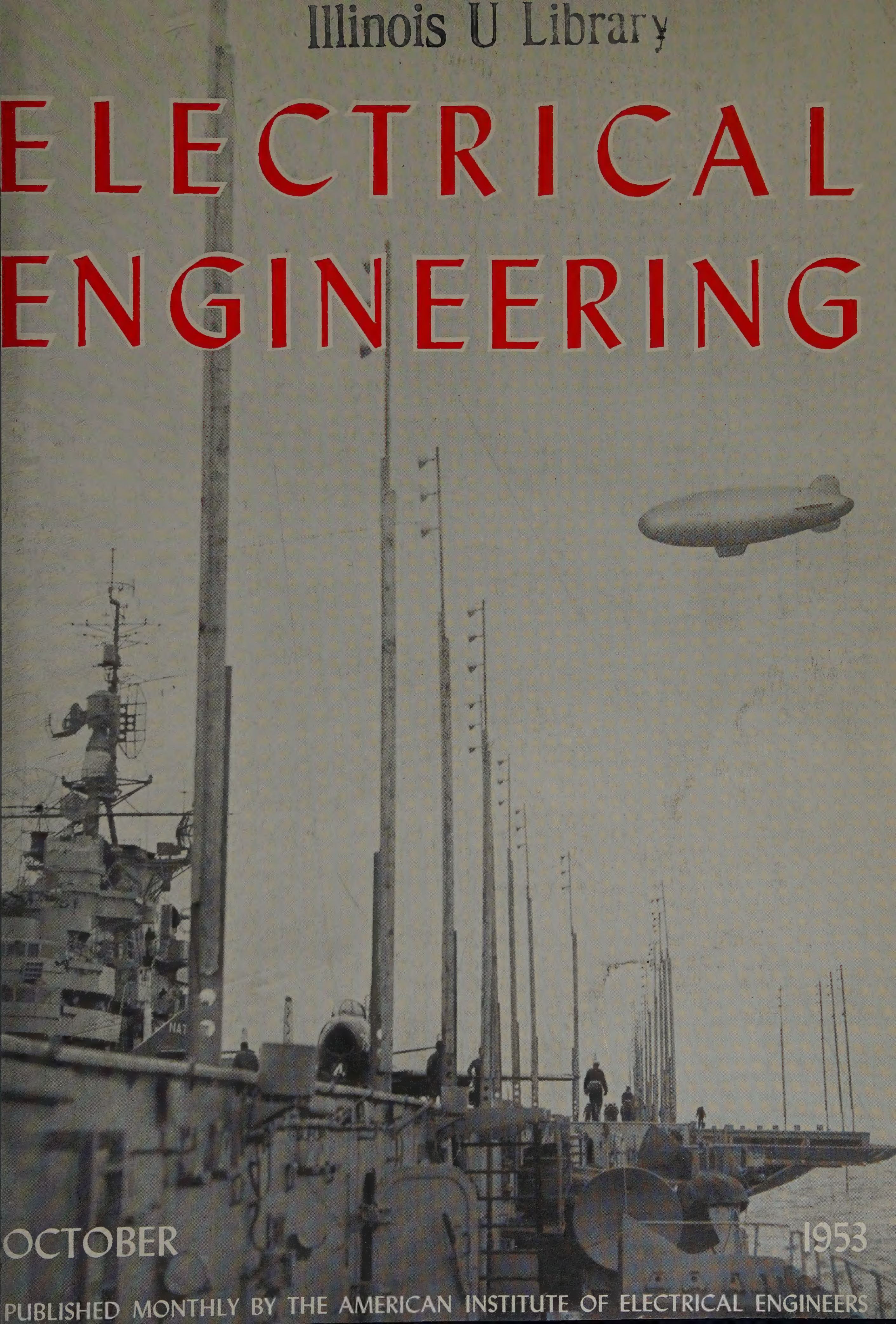
ELECTRICAL ENGINEERING



OCTOBER 1953

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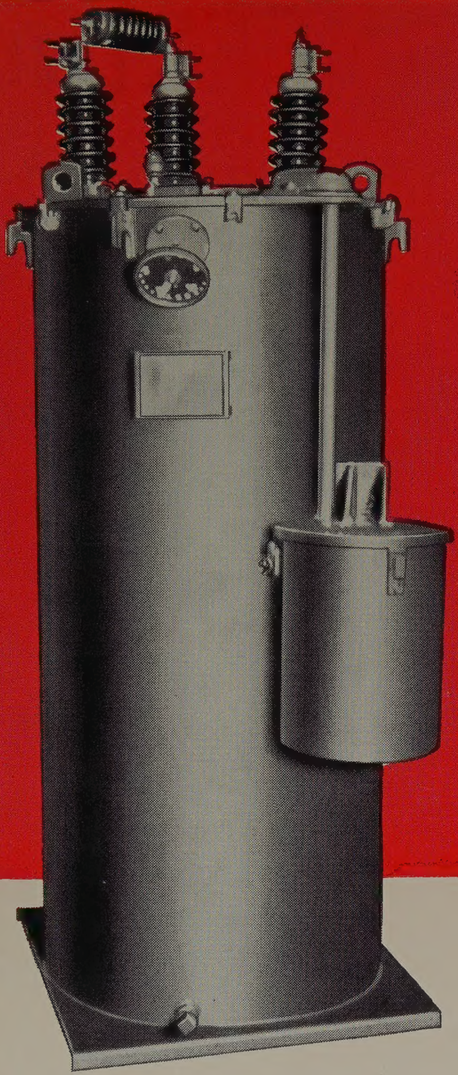

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OCTOBER
1953

The Cover: Shown on this month's cover is the *U.S.S. Antietam*, especially wired with seven flashbulb circuits for the taking of the first color photograph of a jet plane take-off from an aircraft carrier at night. A monochromatic reproduction of the picture, which was taken from the Navy L-type blimp at upper right, will be found with the full story of the event on page 941.

OL. 72 NO. 10

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HIGHLIGHTS........

AIEE Meetings. The industrial growth and development of the Northwest was the theme of the highly successful Pacific General Meeting, held this year in Canada, at Vancouver. Some 65 papers were presented at 19 sessions (*pages 930–2*). The next General meeting of the Institute will be the Fall General Meeting in Kansas City, Mo., in November. A large variety of papers are scheduled, with special emphasis on the petroleum industry (*pages 927–30*). Another future meeting of interest will be the Machine Tool Conference, October 14–16 (*page 933*.

A Psychological Approach to Electronic Complexity. Achieving the optimum complexity for the man-machine system is the objective. Therefore, in addition to fitting the man for the job, the job must be fitted to the man in the sense of not being too complicated or difficult to accomplish yet not so simple as to lack work incentives. Specific examples are provided to clarify the situation (*pages 857–60*).

New Patent Laws. This article points out recent changes in the patent laws and shows how they will clarify and change the situation as it existed prior to January 1, 1953 (*pages 861–5*).

Sliding Contacts' Literature Reviewed. A summation of the work done to date is supplemented by suggestions concerning regions where additional theory and development appear necessary (*pages 912–17*).

Electrets. It is pointed out that they may be made from a variety of materials including many plastics. Theories of electret behavior are examined, and Gross' 2-charge theory found to be most satisfactory; it receives further support from an experiment in which the reversal of an electret is arrested by cooling. Although utilized in practical devices, electrets cannot continuously supply current, energy, or—under most conditions—a potential difference (*pages 869–72*).

Electronics in the AEC Biomedical Program. Electronic devices are finding increasing use in medical research and treatment. The utilization of nuclear energy in such maladies as cancer requires many electronic applications both for control and measurement. Present and future needs are considered (*pages 865–7*).

Communications Synchronizing Systems. A method of approach to the design of synchronizing systems capable of maintaining a high order of accuracy of synchronism in the presence of high noise levels is outlined. The theoretical basis of this method is found in the fields of frequency-modulation communications and servomechanisms (*pages 874–6*).

Sealed Dry-Type Transformers Proved Safe by Test. This transformer with Class *H* insulation was overloaded to destruction without causing either a fire or explosion. With overloads applied in steps up to 600 per cent of rated load, an average winding temperature of 660 degrees centigrade was reached. Thus it is clear that such transformers can be operated with almost no danger of fire or explosion (*pages 894–7*).

Fuses' Role in Appliance Protection. As constantly more complicated appliances become available, adequate protection becomes more of a problem. Fuses offer one solution. All types furnish short-circuit protection, but overload protection is possible only if the time–current characteristic of the fuse is matched with the safe-time–current characteristic of the appliance (*pages 901–03*).

Outdoor Oil Circuit Breakers Operating Under Low Ambient Temperatures. The reliability required of outdoor oil circuit breakers justifies consideration of all aspects of their application. However, for many years the effects of low ambient temperatures have been ignored for the most part. Certain important performance characteristics affected by low temperatures are pointed out which justify specific provisions to maintain a high standard of performance (*pages 907–11*).

Aircraft Antenna Protection From Thunderstorm Discharges. Although the transport aircraft is inherently provided with nearly complete thunderstorm discharge protection by the metal fuselage, movable surfaces and antennas frequently intercept discharges. The antenna-protection unit described protects radio equipment and records the by-passed current and charge magnitudes. Analysis of the sphere gap pitting indicates the total charge transfer, and small magnetic links indicate the peak currents by their magnetization (*pages 880–4*).

Multitransformer Welding Presses. The presswelding method, which can produce from 16 to 160 spot welds practically simultaneously, is admirably suited to many high-production applications. These advantages are enumerated and some of the equipment requirements and techniques applicable to multitransformer presswelding are presented (*pages 919–24*).

Electric Drive for High-Speed Surface-Broaching Machine. The application of an electric drive capable of developing peaks of 600 horsepower to take full advantage of new machine structures and tools is described in detail. Various types of drives are compared, and an analysis is presented of the unit used (*pages 886–91*).

News Index

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers (exclusive of ACO's) presented at General and District meetings. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

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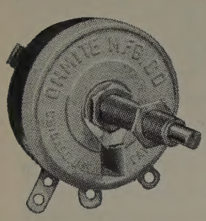

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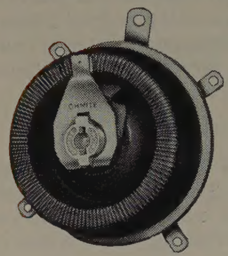
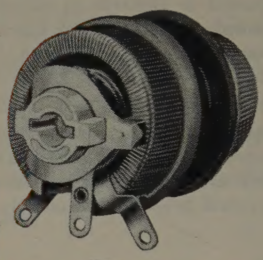


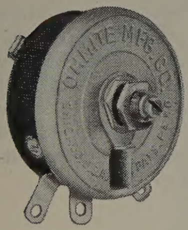
Two small models available with continuous circular core and endless winding. Unlimited rotation of shaft and contact arm. Taps supplied at any desired angle on windings.

DEAD LUG OFF POSITION



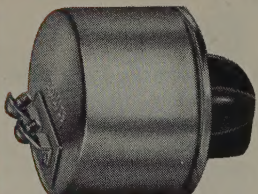
Opens the ci cuit at the hig or low resis ance position a the contac passes on to th lug, which is di connected fro the windin Recommende for light duty.

SCREW DRIVER SLOT SHAFT



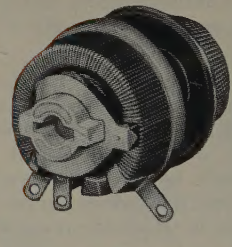
Where infrequent adjustments are needed, shaft ends can be slotted for operation with a screwdriver. Tampering with the shaft setting is thus minimized.

SEALED, ENCLOSED CAGES



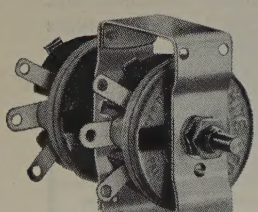
Compact, corrosion-resisting metal enclosure, permanently sealed by a double seam, protects the unit completely. Available with rheostat Models H and J.

SNAP-ACTION OFF POSITION



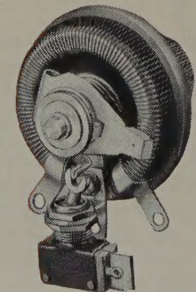
Opens the rhe stat circuit the high or lo resistance po tion. The circu is opened as th brush snaps in an insulate notch next the lug, provi ing indexing.

TANDEM ASSEMBLIES



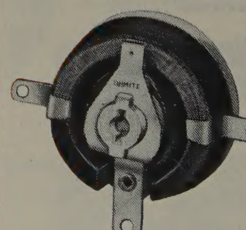
Ohmite rheostats can be mounted two or more in tandem, for simultaneous operation of several circuits. Universal joints provide smooth, positive mechanical action.

TOGGLE SWITCH



Toggle switch is operated with a positive snap by the movement of the contact arm. Opens the rheostat circuit or switches an independent circuit. Available for all models.

LESS THAN STANDARD ROTATION



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A Psychologist Views Electronic Equipment Complexity

B. J. COVNER

One of the problems raised by electromechanical developments in recent years is the impact of new machines and devices upon human behavior, the field with which the psychologist is primarily concerned. Although this situation is only the most recent chapter in a series of events occurring since man began using and then inventing tools, the rapid acceleration in the process has intensified the problem tremendously.

BRIEFLY, the psychologist views electronic equipment complexity as a source of difficulty for human beings in the work they perform. Professionally, he has little or no concern with circuitry or gadgetry as such. He started becoming substantially involved in problems pertaining to electronic equipment during World War II, and his activities in this area have mushroomed ever since. This development undoubtedly parallels developments in electronics as such, and, at first glance, appears anomalous.

The objective of an electronic development is often to replace the human being. Sometimes it is to enable him to do things faster, more accurately, or to do what he was previously never able to do at all. But in line with George Bernard Shaw's classic statement, "whenever science solves a problem, it creates ten new ones," elimination of certain problems caused by human limitations often has resulted in new ones being created.

In power plants, for example, reduced labor costs have resulted from centralized control. But centralized control, coupled with the trend toward increased instrumentation, often means more instruments to watch and raises questions about how best to design and arrange instruments and controls to permit most efficient operator performance. Further, as more operations are automatized, the operator has less opportunity to practice certain skills that are required in an emergency. Here arises a curious situation in which the operator has relatively little to do most of the time (leading to boredom), but during an emergency must do immediately a great many things that he never has done in exactly the same way before. Also, as Hardin has pointed out, where automatic power plant equipment is installed there is a strong tendency to neglect even minor maintenance duties to the point where equipment failures are still fairly common.*

Atomic energy developments have made possible new kinds of laboratory tests, but they also create problems of remote-control manipulation. What, for example, is the optimum relationship of master-slave displacement to achieve a specific degree of manipulative accuracy? How much force should be applied at the master unit? How much "feel" should be simulated? Improvements in ordnance and fire control have made possible increased rates of fire, and faster, more precise, target detection. But often there is a disparity between inherent weapon accuracy and operational performance because the operator fails in some way.

Perhaps the best known example of the impact of electromechanical improvements on the operator is the airplane cockpit. Many studies of accidents have shown the cause to be instrument-reading errors and confusion of controls. An air-line pilot recently stated at an Institute of Aeronautical Sciences meeting that when he entered the flight deck of his twin-engine airliner, he was confronted by 85 switches, 50 controls, and 90 indicators. Military pilots have all this and specialized military equipment too. There is a growing fear that additional cockpit instrumentation will result in poorer rather than better pilot performance. In fact, there is increasing talk about developing entirely new methods of instrumentation that will be more compatible with the pilot's abilities.

Electronic digital computers are affecting jobs in new and interesting ways. These ingenious devices, while eliminating tedious hand computations, create the bottleneck job of programming. A programmer in the computer laboratory of an aircraft company, describes his work in this way: "It requires painstaking skill to set up the problem, but running it off is just a bore." This feeling is consistent with a point made recently that engineers now should give greater attention to the input and output aspects of computer design.[1]

A well-known concomitant of increased complexity of electronic equipment is increased maintenance. This difficulty is becoming quite serious as factories are automatized. While operators drop in number, maintenance workers increase, raising the cost of maintenance to as much as 15 per cent or more of each sales dollar. Other problems arise, too. For example, in the usual machine shop, all machines of a given type are grouped in one area. Maintenance men easily can see what is happening. However automatized machines may be 100 feet long,

* "Maintenance of Instruments, Controls, and Safety Devices for the Safe Operation of Power Boilers," **T. R. Hardin.** Paper presented at regional conference on Power Plant Instrumentation held by the New York Section of the Instrument Society of America, February 8, 1952.

Revised text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953, and recommended for publication by the AIEE Committee on Electronics.

Dr. B. J. Covner is product development co-ordinator with Dunlap and Associates Inc., Stamford, Conn.

which makes it impossible for mechanics to see and hear each other, and requires installation of a special communications system for them.

Underlying each of the examples just cited is the simple fact that while electromechanical equipment has undergone many developments, human beings remain essentially unchanged. Often the new equipment developments place demands upon humans which exceed their psychological and physiological capacities. One upshot of this situation has been the development of a new field of work for the psychologist—human engineering, or engineering psychology. More traditional activities of the psychologist, such as scientific personnel selection and training, which were primarily concerned with "fitting the man to the job," were found to be insufficient. While doing as much in these more traditional areas as possible, it became necessary, in addition, to concentrate directly on machines with the aim of fitting the job to the man.

JOB COMPLEXITY AND HUMAN PERFORMANCE

MUCH OF THE TALK ABOUT equipment complexity and its effect upon human performance is somewhat misleading. The trend has been to view the problem as one in which the poor human gradually is being surrounded and choked by instruments, controls, and gadgets. In reality, however, job complexity has an impact on performance long before equipment reaches this stage. One of the most startling things about the relationship between job complexity and human performance is that the equipment a person uses does not have to be very complicated to hamper his performance.

In one make of automobile, for example, the speedometer arrow is red, the dial face black, and the numerals green, resulting in extremely poor contrast and legibility. In addition, the horn ring on the steering wheel makes it practically impossible for drivers of certain heights to read the speedometer without contorting their necks.

An even better illustration of this point is a hearing aid that is small, light, and attractive, and that probably would be looked upon as an excellent example of miniaturization. From an actual use standpoint, it has several things wrong with it. While reading the following list of shortcomings, it should be kept in mind that hearing aids are used increasingly by older people whose perceptual and manipulative skills are on the downgrade, and who, as a group, are increasing in numbers.

1. The clip that attaches the device to the wearer's clothing is extremely hard to open.
2. Volume and pitch controls, which require thumb adjustment, have notches so small that movement and accurate adjustment are extremely difficult. Also, the numerals on these controls are too small to be read without considerable difficulty.
3. The on-off switch gives no direct tactual or visual indication of being on or off. To determine that the switch is off the user either has to listen for a click, or push the control several times to know that it can be pushed no further.
4. The ear piece is well-designed to fit comfortably, but considerable fumbling is necessary to insert it properly. Perhaps moulded finger grips would aid in positioning the piece for insertion.
5. While the instructions advise removal of the battery every night, there is no latch or handle or pull-apart feature for reaching the battery easily. It is actually necessary to pry open the door with a finger nail.
6. The microphone-telephone switch is so small that it is extremely difficult for the average person to operate it.

The significance of such "simple" shortcomings depends of course upon the situation. Certainly they can have an unfavorable effect upon customer satisfaction. This point alone carries great weight in a buyer's market particularly as the buying public becomes more sophisticated in its wants and shopping methods. In certain instances simple shortcomings can have profound significance. To take a dramatic example, investigation of a recent major air crash showed that a single control was only partly unlocked. As a result, the pilot was able to control the airplane well enough to taxi, but not well enough to take off. This control was a handwheel. If it had been a simple, 2-position lever (locked, unlocked) there certainly would have been less chance of this tremendously costly error occuring.

Tinted windshields for automobiles illustrate still another aspect of the problem. For some time it has been known that tinted windshields, while reducing glare, cut down on night visibility, particularly among older drivers. To make matters worse, the following excerpt shows what can happen when designers fail to consider adequately the uses that people make of equipment—in this case, uses other than transportation:[2]

> Tinted windshields bring howls of anguish from owners of drive-in theatres.
>
> Customers, they contend, complain that glare-resistant windshields blur black-and-white pictures, make Technicolor unrecognizable and render useless the Polaroid glasses used for viewing one type of 3-D picture.
>
> A campaign has been launched by the International Drive-In Theatre Owners Association to persuade auto makers to attack the problem of glare some other way. It argues that tinted windshields reduce vision on the road, are a safety hazard, and "distort the picture at drive-in shows."
>
> With five million cars slated to get hued windshields in the next 18 months, drive-in owners hope auto makers will develop a tint that doesn't impair movie viewing.

Can the relationship between job complexity and human performance be expressed mathematically? While there is no simple formula to include all instances, the answer to this question is decidedly "yes." Textbooks of experimental psychology abound with results of laboratory experiments which show, for example, what happens to reaction time as the stimulus varies in type (visual, auditory, tactual), or as the individual is instructed to respond to one type of stimulus and not to another. In fact, one of the oldest of psychological laws, that of the relationship between a person's awareness of a stimulus and the strength of the stimulus, is $S=k \log r$ (S stands for sensation or

awareness, k for a constant, and r for the stimulus strength).

For the most part, however, the engineer is more concerned with the solution of practical problems than with what laboratory experiments conducted under somewhat unrealistic conditions have shown. Here, for example, are the results of an experiment which shows the relationship between job complexity and human performance in a practical situation. The experiment was a step in designing a unit of electronic equipment.

Eighteen subjects performed 16 tracking problems under six conditions. These conditions consisted of various combinations of *good*, *average*, and *poor* displays with *good*, and *poor* controls. The displays were mock-ups of indicators that are commonly used in electronic installations. The controls were mock-ups of handwheels and a joystick. The operator's task was to return a moving pointer on a display to zero by manipulating either a joystick or two handwheels.

Control-Display Combination	Per Cent of Responses in Error
Good control–good display	less than 1
Good control–average display	10
Good control–poor display	29
Poor control–good display	10
Poor control–average display	18
Poor control–poor display	33

These results illustrate the principle that there must be a natural or expected relationship between controls and displays to obtain best performance. Unnatural relationships require the operator to make unnatural movements. Such movements require longer learning, and tend to break down under stress conditions.

Another factor of considerable importance is the effect of job complexity upon reaction time. In the experiment just cited, average reaction time for the good control–good display combination was one-fifth that for the poor control–poor display combination. The actual time difference was 2 seconds. The significance of this type of information becomes readily apparent when one considers that in 2 seconds an automobile traveling at only 60 miles per hour covers 176 feet. And when one considers the multimillion-dollar, tremendously high-speed aircraft, missiles, and so forth that engineers are designing today, this information has even greater significance.

ENGINEERING DECISIONS AND JOB PERFORMANCE

LET US NOW relate the fact that job complexity has an impact on job performance to the decision-making function of design engineers. The following list presents typical questions that often must be considered in reaching design decisions:

How difficult is this equipment to operate?
How difficult is it to maintain?
What kinds of people are required to perform these duties?
What are the chances of obtaining them?
How long would it take to train them?
How safe are the jobs?
How comfortable are working conditions?
What modifications would make the equipment easier, safer, and more comfortable both to operate and maintain?

And, more specifically:

What information do users need?
How may this information best be presented?
What controls must the user manipulate?
How rapid and accurate must his manipulations be?
What kinds of decisions must he make?
How should controls and indicators be designed and arranged?
How can communications facilities best be integrated into the work place?
Should seats be provided?
What limits do human body measurements impose on the location and arrangement of indicators and controls?
What kinds of illumination are needed?
To what extent do noise, heat, and vibration affect performance?

It is immediately apparent that these questions deal with human performance, and are primarily concerned with surface rather than more basic aspects of equipment design (except for maintenance operations). They are not concerned with complexity of circuitry or gadgetry as such.

The equipment designer probably will be responsible for the design decisions made with reference to these questions. There is some question, however, as to the amount of help he will require from human engineers. In many instances, of course, solutions are obvious if the designer is merely aware of the problem. The pity of it is, of course, that all too often either these human performance questions are not called to his attention, or he is so concerned with regular engineering problems that he has not time to deal with the human engineering problems adequately. Frequently what appears to be an obvious solution really is not. Also, the human engineering issues involved are often quite complex, and become controversial. It is in situations of this sort that the human engineer can be of most help in making equipment work as it is supposed to.

The value of human engineering and of a human engineering viewpoint to design engineers is becoming increasingly recognized. Some electrical engineers, for example, have become ardent students of human engineering literature. Another example is the following recommendation of the Research and Development Board, Department of Defense:[3]

8.1.4. Inclusion of Consultation Service Clause in Contracts: As a means of ensuring that development contractors give adequate attention to human characteristics, it is recommended that contracts for major equipment items and systems, in which the existence of human operator problems can be foreseen, include a clause requiring human engineering consultation service.

ANALYSIS OF MAN-MACHINE SYSTEM TELLS WHERE BEST TO APPLY HUMAN ENGINEERING

ORIGINALLY THE APPROACH OF the human engineer was to start directly on the improvement of individual system components. He would concentrate on making a

radar scope more readable, or a seat more comfortable, or a switch more accessible and manipulatable. This happened partly because of his own lack of sophistication, and partly because he was given only a single unit of the system to work on. But as man-machine systems increased in complexity, and as he gained experience in working on complex systems problems, his approach changed.

At the present time the human engineer tends more and more to end rather than start with the improvement of individual components. Since his work is aimed at improving the performance of an entire system of men and machines, he must determine first what is meant by "improvement," and what kinds and amounts of improvement can be obtained by various courses of action.

Consequently, to the greatest extent possible, he takes great pains to analyze and obtain measures of performance throughout the system. Such information helps tell him both the need for and value of improvement at various spots in the system. It is not uncommon in making such an analysis, to discover that the saving of several seconds by simple human engineering changes involving practically no cost can improve system performance by as much as 80 per cent, while other improvements involving tremendous cost would contribute very little to system performance.

He also finds that commonly used criteria such as speed, accuracy, legibility, comfort, and so forth, are often misleading as well as antagonistic. Making it possible to do something more accurately, for example, may result in slowing down the response to the point where it occurs too late to be helpful.

The real goal of a man-machine system is not speed, accuracy, or comfort. Instead it is providing transportation to a community, destroying enemy aircraft, producing ships, or other such objectives. The way in which such criteria as speed, accuracy, and so forth, contribute to the goal is generally complex and often obscure. Taking the pains to ferret these factors out, however, can be very rewarding in helping to attain the system's optimum net value.

OTHER PSYCHOLOGICAL ASPECTS OF EQUIPMENT COMPLEXITY

THE MORE TRADITIONAL areas of the psychologist concerned with "fitting the man to the job," such as scientific personnel selection and training, are still important. For example, a psychologist who has been studying some of the human problems of the automatic factory reports:

. . . . emphasis will shift from manual to "mental" skills. We can replace an operator's judgment and production skills with a machine. But we can't replace the knowledge needed to create the machine, to manage it, and to service and maintain it.

More engineers, technicians, and skilled maintenance men will be needed. So the automatic plant certainly won't dispense with people. It will just demand different *kinds* of people. Here's an example: Recently a representative of a company that is interested in magnetic tapes for programming automatic machines got to talking about the kind of setup man such machines would need.

"They'll have to feed the magnetic tape directions derived from engineering drawings. The directions will be equations that will guide the servomechanisms in the machine too," he commented. "Not an easy job. In fact, it looks as though the setup man is going to have to be an engineer."[4]

Motivation is another psychological aspect to consider. As equipment becomes more automatic, or as jobs become simplified, it becomes increasingly difficult to provide people with incentives for work. Numerous studies have shown, for example, that as jobs became more simplified, and certain inherent satisfactions were removed from skilled jobs, labor unions became increasingly attractive as a new source of satisfaction.

Here is evidence, as well as a warning, that making jobs as simple as possible, while an appropriate goal in some instances, is not universally desirable. It is necessary to think more in terms of optimum complexity rather than utmost simplicity. Some companies, as a matter of fact, have started already to enlarge jobs in order to make them more satisfying. Of course, equipment design should not be expected to do the whole job of providing adequate motivation. Enlightened management still must play an important role.

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3. The Role of Human Engineering in National Defense: Recommendations for Increased Effectiveness, prepared by **The Panel on Human Engineering and Psychophysiology Committee on Human Resources.** HPS 107/1, May 24–26, 1952.

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Transistor Microscope

A transistor microscope, designed specifically for use in the assembly and inspection of transistors and other miniature electronic units, has been announced by the Bausch and Lomb Optical Company.

The instrument has features suggested and field tested by transistor manufacturers and is designed to be incorporated into production-line and inspection setups.

With the new microscope the operator uses both eyes and sees the magnified image in the same aspects as without the instrument—in three dimensions, with natural movements, and right side up. Total magnifications from 6.6 to 150 times may be selected. Operator physical fatigue and eyestrain, which lead to rejects and spoilage, are prevented by inclining the eyepiece 30 degrees.

The optical head rotates through 360 degrees and thus may be set at the most comfortable operator position, regardless of the machine on which it may be mounted.

Because field tests showed that spacing, bending, and welding of transistor "whiskers" are done at one selected magnification, deep-focus objectives are provided, eliminating refocusing after the original setup has been made. The microscope is both rugged and highly precise.

The New Patent Laws

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For a number of years, various judicial interpretations of the patent laws have been the subject of much controversy in the patent field. With the first of the year, new statutes went into effect which should do much to clarify the situation.

On January 1, 1953, new patent laws went into effect, settling a number of issues that had vexed the industry and the patent bar for over a decade. These issues were raised by a number of court decisions that had overturned some of the traditional ideas on patentability, validity, contributory infringement, abuse of patent monopoly, and so on. One who has followed the Supreme Court decisions in other fields well might have expected the court to maintain a very strict attitude against monopoly of all kinds.

Although the patent system, granting an inventor exclusive rights to his invention for a fixed period, was sponsored by the Constitution expressly "to promote the progress of science and useful arts" in the long-term interest of the public, and was enacted into detailed laws by Congress, yet a judicial authority oversensitive to monopoly could go far towards limiting the patent rights by judicial interpretations; and that was what many observers thought was happening, even though the Supreme Court did profess repeatedly great benevolence to those who have made important inventive contributions to the useful arts.

Some of these issues and the bearing of the new statutes on them will be reviewed in this article.

THE SITUATION UNTIL RECENT YEARS

Since the earliest days of our patent system, it has been recognized by the courts that there is not a simple single universal formula to test whether or not a given idea or device constitutes a new inventive advance over the prior art. So, in course of time, the courts had evolved a number of negative and a few positive tests of invention applicable in special cases. For instance, it had been recognized that generally no invention is involved in: (*a*) merely making something larger or smaller; (*b*) making old separable parts integral, or a 1-piece device in several parts; (*c*) making an element adjustable; (*d*) omitting part of an old device if the function of that part also is omitted; (*e*) making an aggregation of several devices as one article (pencil with eraser attached); (*f*) rearranging the parts of an old device with no new result; (*g*) changing the order of the steps of a process with no significant new result; (*h*) duplication of parts; (*i*) substitution of better materials; (*j*) substitution of well-known equivalents; (*k*) changing the proportions of the ingredients with no particular new result; (*l*) new use of an old device; (*m*) utilizing an element or expedient old in an analogous art; (*n*) greater purity of chemical; (*o*) carrying an old idea a little further in the same direction; (*p*) making an old device portable; (*q*) imitating a device or an effect; (*r*) a combination of old parts or processes that would be obvious to one with average skill in that field, and so forth.

On the positive side, invention had been recognized by the courts in: (*a*) a process or device that produces an unobvious result; or (*b*) one that is based on a new principle or discovery; or (*c*) one that has brought success out of a line of failures in its field; or (*d*) one that has filled a long-felt need; or (*e*) one that is based on the recognition of a problem that others had failed to recognize; or (*f*) one that combined two or more old parts or processes in a new manner to produce a final result that is new to the component parts or processes; (*g*) one that was contrary to a widely held notion and successful; (*h*) one acknowledged by competitors as invention (for instance, by acceptance of licenses); (*i*) one with a marked improvement in efficiency, and so forth.

Guided by such principles the Patent Office had been processing several hundred thousand patent applications a year when, in 1941, the Supreme Court startled the legal profession with a new doctrine on patentable invention.

"THE FLASH OF GENIUS" ARGUMENT

In "Cuno Engineering versus The Automatic Devices Corporation," the Supreme Court was considering an infringement suit involving the patent on the cordless and thermostatically controlled cigar lighter now very common on automobiles. The claims of the patent in suit were invalidated in these strong words:

> . . . The new device, however useful it may be, must reveal the flash of creative genius, not merely the skill of the calling . . . Strict application of that test is necessary lest in the constant demand for new appliances the heavy hand of tribute be laid on each slight technological advance in an art. (*5340G699*)

Much earlier (1930), the Third Circuit Court of Appeals had spoken in great contrast to this, as if with a prophetic anticipation of it. It had said:

> Invention is not always the offspring of genius; more frequently it is the product of plain hard work; not infrequently it arises from accident or carelessness; occasionally it is a happy thought of an ordinary mind; and there have been instances where it was the result of sheer stupidity. It is with the inventive concept, the thing achieved, not with the manner of its achievement or the

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quality of the mind that gave it birth, that the patent law concerns itself. (Radiator Specialty Company versus Buho. *30F. 2d 373*)

In demanding "the flash of creative genius," was the Supreme Court raising the requirement for patentability? Many lawyers and judges thought so, even though the Supreme Court seemed to imply that this was always the law. Some few thought that the Court had used an unfortunate rhetorical phrase without quite meaning it. But there was not any doubt left as the majority of the patents that subsequently reached the Supreme Court were invalidated, the Court repeating the "flash of genius" test. Furthermore, in more than one case, the justices severely criticized the Patent Office for granting patents so easily.

In "A&P versus Supermarket Equipment Corporation," Justice Douglas and Black had this to say in a supplementary (concurrent) opinion:

> . . . The attempts through the years to get a broader, looser conception of patents than the Constitution contemplates have been persistent. The Patent Office, like most administrative agencies, has looked with favor on the opportunity which the exercise of discretion affords to expand its own jurisdiction. And so it has placed a host of gadgets under the armor of patents—gadgets that obviously have had no place in the Constitutional scheme of advancing scientific knowledge . . . The patent involved in the present case* belongs to this list of incredible patents which the Patent Office has spawned. The fact that a patent as flimsy and as spurious as this one has to be brought all the way to this Court to be declared invalid dramatically illustrates how far our patent system frequently departs from the Constitutional standards which are supposed to govern. *(87USPQ303 6420G5)*

Several appellate courts followed the Supreme Court's demand for a higher standard of invention, but Judge Evans of the Seventh Circuit Court of Appeals (Illinois) had this to say on the matter:

> . . . We are advised and believe that in the field of science nearly all advance is made in laboratories where many experiments are made and discoveries result from the trial and error method. . . .
>
> The test of "flash of genius" should be rejected not only because it is incapable of acceptable definition but because it injects into the statute something not appearing therein. The Federal decisions covering a century contain many to the effect that it is the fact of accomplishment . . . rather than the method of accomplishment with which judicial inquiry is concerned. . . . (Chicago Steel Foundry Company versus Burnside. *56USPQ283*)

The Patent Office continued its function in its customary conscientious manner to promote the useful arts by rewarding the inventors with patents.

But such a situation could not be allowed to continue indefinitely—the Patent Office issuing patents and the Supreme Court knocking them down. Justice Jackson of the Supreme Court was alarmed over this situation and chided his associates as follows:

> It would not be difficult to cite many instances of patents that have been granted improperly. . . . But I doubt that the remedy for such Patent Office passion for granting patents is an equally strong passion in this Court for striking them down so that the only patent that is valid is one which this Court has not been able to get its hands on. (Jungersen versus Ostby. *80USPQ32*)

The situation called for remedial legislation, and while that was in the making, a few still more startling decisions came out of another court.

STRANGE DOCTRINES FROM THE DISTRICT OF COLUMBIA COURT OF APPEALS

Many will remember Thurman Arnold as the one-time antitrust attorney of the Justice Department, who later was appointed to the Court of Appeals of the District of Columbia. During his brief service there, that court pronounced several revolutionary doctrines.

(*a*) The doctrine that not the character of the product but the mental process of the inventor counts.

The case before the Court was an improved teletype machine for an automatic stock quotation board. The fact that first the Patent Office, and then the Board of Appeals, and then the District Court had rejected the claims in suit would suggest that these claims must have been pretty weak. But what startled the patent world was not that these claims were rejected but that the Court had made the following doctrinal pronouncements:

> . . . In determining whether an invention has been made, the character of the article or process, its novelty, and its advance over the prior art are merely evidentiary, and the ultimate question is the character of the inventor's contribution; there being no invention without inventive genius. The objective advance does not identify or evaluate the individual achievement. (Potts et al. versus Coe. *140F2d470*)

Not even the Supreme Court had gone to such an extreme. That Court merely had said that "the new device (not the inventor or the method of invention) . . . must reveal the flash of creative genius." The genius incorporated in the new device could have been an accidental discovery. But as Judge Arnold wrote the doctrine, the nature of the device and its advance over the prior art are merely "evidentiary," and for patentability the ultimate test is how the invention was made, whether by inventive genius or by some other process.

But what other process could the court be thinking of? Two were mentioned: (1) exhaustive experimentation, and (2) in a big laboratory. These were covered in the following strange doctrines.

(*b*) "Neither the result of great industry in experimental research nor the successful product of a gradual process of experimentation over a period is invention."

The Court said further,

> . . . a step forward which . . . might reasonably be ex-

* The patent concerned a sliding counter with only three sides and an open end, to be seen in A&P supermarkets to push the groceries to the checker and be withdrawn without pulling the groceries back.

pected from the research of highly trained specialists is not invention . . . Routineering, even by the most highly trained specialists, step by step improvements, the carrying forward of a new and more extended application of the art, are not invention.

(*c*) The patent laws as they stand apply to individual inventors making inventions for themselves, and not to inventions made by "captive inventors" in the laboratories of big corporations.

To quote the Court's own words:

> . . . patents are not intended as a reward for a highly skilled scientist who completes the final step in a technique, standing on the shoulders of others who have gone before him. By the same token they are not intended as a reward for the collective achievement of a corporate research organization . . . The inventor is paid only a salary, he gets no royalties, he has no property rights in the improvements which he helps to create. . . To give patents for such routine experimentation on a vast scale is to use the patent law to reward capital investment, and create monopolies for corporate organizers instead of men of inventive genius. . . Organized invention has changed the entire process (of invention) . . . Because the captive inventors in these great laboratories have no control over their patents, the corporation may distribute the very right to apply for a patent among its employees in accordance with sound business policy. . .
>
> Prior to the development of corporate research the circumstances under which the alleged invention was made were ordinarily not examined. The oath of the applicant was considered as a sufficient prima facie showing of invention provided the article itself was sufficiently novel. But today where the record shows that the real party in interest is a vast research organization possessing advantages not available to the outside scientist it would be contrary to modern experience to assume that the burden of proving the presence of inventive genius has been met without evidence disclosing the level of the art in that research organization at the time the application is made. This principle emphasizes the importance of individual achievement, which is the aim of the patent law . . . to reward individual and not group achievement. . .

The reader will have noted that many of these statements are inaccurate and distorted, because the Court's thinking was apparently dominated by an ideology, and that nothing short of explicit statutes regarding these matters would alter its reasoning.

THE ARGUMENT OVER CONTRIBUTORY INFRINGEMENT

It was a doctrine of long standing evolved by the Courts that where a person manufactures or sells an unpatented part of a patented combination with the knowledge that it is to be used to infringe that patent, and this part is not a regular article of commerce and does not have a substantial noninfringing use, that person is guilty of contributory infringement.

In the patent infringement suit of "The Mercoid Corporation versus Mid-Continent Investment Company et al. (*60USPQ21*)" decided in 1941, involving a triple thermostatic furnace control system, the Supreme Court found the plaintiff guilty of monopolistic practices beyond the scope of the patent, and would not give it the relief asked for against the contributory infringers; but then the Court went further, making these startling declarations:

> Leeds and Catlin versus Victor Talking Machine Company (number 2) . . . authority for the conclusion that he who sells an unpatented part of a combination patent for use in the assembled machine may be guilty of contributory infringement . . . is in substance inconsistent with the view which we have expressed in this case. . . . The result of this decision, together with those that have preceded it, is to limit substantially the doctrine of contributory infringement. What residuum may be left we need not stop to consider. . .

In a dissenting opinion, Justice Frankfurter defended the old doctrine of contributory infringement:

> . . . the misapplication of a formula . . . is a poor excuse for rejecting the idea. It will be time enough to define the appropriate limits of the doctrine of contributory infringement when we are required to deal with the problem. Until then litigants and lower courts ought not to be embarrassed by gratuitous innuendoes against a principle of the law which, within its proper bounds, is accredited by legal history as well as ethics. . .

Rebutting Justice Frankfurter, Justice Black argued that as long as there is no statute explicitly forbidding contributory infringement, "morals" and "ethics" have nothing to do with the matter. To quote his exact words:

> . . . for judges to rest their interpretations of the statutes on nothing but their own conceptions of "morals" and "ethics" is, to say the least, dangerous business. If the present case compelled consideration of the morals and ethics of contributory infringement, I should be most reluctant to conclude that the scales of moral value are weighted against the right of producers to sell their unpatented goods in a free market.
>
> . . . I wish to make explicit my protest against talking about the judicial doctrine of "contributory infringement" as though it were entitled to the same respect as a universally recognized moral truth.

LEGISLATIVE RELIEF

In a few simple sentences, the new statutes clarify the controversial matters.

1. On flash of genius and long experimentation, the new statute says:

> Patentability shall not be negatived by the manner in which the invention was made. (*35USC102*)

The House Judiciary Committee that sponsored these revised laws makes this comment on this statute:

> That is, it is immaterial whether it resulted from long trial and experimentation or from a flash of genius.

2. How important must the invention be to be patentable?

The old statute said,

> . . . if . . . the same is sufficiently useful and important, the commissioner shall issue a patent therefore. *(35USC'46Ed.36)*

That left it to the Patent Office and the courts to decide how useful and how important an improvement must be to rise to the dignity of a patentable invention, and the Supreme Court required "flash of genius." The new statute *(35USC131)* omits that "sufficiently useful and important" clause altogether, and the comment of the Judiciary Committee is that this clause "is omitted as unnecessary, the requirement for patentability being stated in sections 101, 102, and 103." But all that these sections say regarding usefulness and importance is that:

> Whoever invents or discovers any new and useful process, machine, manufacture or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title. *(35USC101)*

The old requirement that the invention be "*sufficiently* useful and *important*" is gone and the word "important" appears nowhere, taking away from the courts the privilege of laying down heavy requirements.

Still, the new statutes do not permit the patenting of every trivial and obvious thing just because it is new. There is this wise provision in section 103:

> A patent may not be obtained though the invention is not identically disclosed or described as set forth in Section 102 of this title, if the difference between the subject matter sought to be patented and the prior art is such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *(35USC103)*

To be a patentable invention then, the improvement will have to be more than what would have been obvious at the time to a *person having ordinary skill* in that art.

The older decisions used to refer to a "person skilled in the art," and an invention was supposed to be something more than what would be expected of him to construct. Some courts had gone farther and defined this skilled person as a "routiner." The new statute defines him clearly as "a person with *ordinary skill* in the art," and requires that the invention be, not something that such a person could not devise by trial or hard work or concentrated thinking, but something that would not have been *obvious* to him. This new standard appears even more moderate than the old one used by the Patent Office and many of the courts.

3. On contributory infringement, the new statute says:

> (*c*) Whoever sells a component of a patented machine, manufacture, combination or composition, or a material or apparatus for use in practicing a patented process, constituting a material part of the invention, knowing the same to be especially made or especially adapted for use in an infringement of such patent, and not a staple article or commodity of commerce suitable for substantial noninfringing use, shall be liable as a contributory infringer. *(35USC271)*

The House Judiciary Committee comments on this at some length, stating that

> The doctrine of contributory infringement has been part of our law for about 80 years . . . has been characterized as "an expression of both law and morals."

4. May a person be held liable under antitrust laws for making legitimate use of his patent monopoly? What are the legitimate uses?

Three tests are given for this:

> No patent owner otherwise entitled to relief for infringement or contributory infringement of a patent shall be denied relief or deemed guilty of misuse or illegal extension of the patent right by reason of his having done one or more of the following: (1) derived revenue from acts which if performed by another without his consent would constitute contributory infringement of the patent; (2) licensed or authorized another to perform acts which if performed without his consent would constitute contributory infringement of the patent; (3) sought to enforce his patent rights against infringement or contributory infringement. *(35USC271)*

A discussion of the bearing of these rules on typical situations adjudicated during the past 10 to 15 years would go beyond the scope of this article.

5. May a patent be invalidated because of some innocent legal defect dug up by an infringer?

For example, (*a*) due to some uncertainty as to exactly who made the invention, the patent may have been sworn to by more or fewer persons than the right ones, called "misjoinder" and "nonjoinder" of inventor, respectively; or (*b*) two related inventions may have been covered in one patent, instead of separate patents; or (*c*) when an invention is "double-patented," the office requiring the division of an application into two for separate parts of an invention, and the court holding that there is only *one* invention and *two* patents have been issued for it, making them invalid; or (*d*) one or more claims may be in improper form or invalid, though the rest are all right.

On these matters the new statutes say:

> a. The misjoinder or nonjoinder of joint inventors shall not invalidate a patent. . . if it can be corrected. *(35USC256)*
>
> b. The validity of a patent shall not be questioned for failure of the Commissioner to require the application to be restricted to one invention. *(35USC121)*
>
> c. A patent issuing on an application with respect to which a requirement for restriction . . . has been made, . . . shall not be used as a reference either in the Patent Office or in the courts against a division application or . . . any patent issued on either of them. . . *(35USC121)*
>
> d. Whenever, without any deceptive intention, a claim of a patent is invalid the remaining claims shall not thereby be rendered invalid. *(35USC253)*

And there are other such protective clauses for innocent inventors.

6. Inventions made in large laboratories.

Not a word is to be found either in the statutes or in the report of the Judiciary Committee regarding inventions made in the attic and those made in large research laboratories. The Committee report and comments are models of great tact.

7. False marking as "Patented" or "Patent Applied for" or "Pat. Pending"

> . . . shall be fined not more than $500 for every such offense. Any person may sue for the penalty, in which event one-half shall go to the person suing and the other to the use of the United States." (*35USC292*)

In the foregoing, "every such offense" means every piece of article falsely marked so. The old penalty was "not less than $100."

Will these statutes accomplish the intent of Congress? So far as contributory infringement is concerned, it can be assumed the Supreme Court will enforce the new laws.

Also, so far as the method of making of an invention is concerned, the courts may be counted on to use an objective test hereafter, instead of a subjective one, that is, a test based on the character of the improvement and not on that of the improver.

So far as the criterion of the quality of invention is concerned for patentability, this writer is inclined to believe that the Supreme Court will continue to insist on a high standard. The new statute in section 103 can be construed as favoring a high standard of invention.

So far as the antitrust aspects of the matter are considered, it surely was not the intent of Congress to weaken the antitrust laws, and this writer expects that the Supreme Court will continue to insist on "clean hands" under a magnifying glass.

Electronics in the AEC Biomedical Program

J. C. BUGHER

The general way in which electronic phenomena are applied to the problems of human ills is reviewed and the activities of the United States Atomic Energy Commission's Division of Biology and Medicine are outlined. In addition, certain lines of development in the immediate future, which anticipated requirements make desirable, are indicated.

MEDICINE, like many other branches of applied knowledge, owes much to the young and rapidly developing science of electronics. In the development and application of knowledge to the understanding and alleviation of human disease, every branch of science is involved and every broad subdivision of technology eventually contributes something of its own to this complex. In a general sense, the applications of electronic science to medicine fall into a few well-defined categories.

THE DEMONSTRATION OF THE CHARACTER OF PHYSIOLOGICAL PHENOMENA

THE BASIC UNDERSTANDING of physiological processes oftentimes is largely qualitative. Particularly when the phenomenon occurs within a short time span, measured in fractions of a second to a few seconds, a qualitative or roughly quantitative demonstration of the succession of events may be of great value. Thus the use of the cathode-ray oscilloscope to visualize the sequence of electrical phenomena in the transmission of a nerve impulse makes possible a new research approach to a very fundamental problem in physiology. Similarly, the extension of electronic techniques to the demonstration and recording of transient electrical states of longer time periods, as in electroencephalography, may yield significant research and diagnostic information in hitherto obscure and difficult fields of study.

An outstanding example of the utilization of an electron beam for visualization of form and structure is the electron microscope, now of such general utility in all fields of biology.

THE QUANTITATIVE MEASUREMENT OF REACTIONS OR PRODUCTS

RESEARCH IN BIOCHEMISTRY, for example, requires constant improvement in the techniques of measurement of reaction velocities and the concentrations of the end products in processes involving inherently delicate compounds where it is important that the method of measurement does not itself significantly alter the reaction. The development of the glass electrode for the measurement of hydrogen-ion concentrations in biological materials is a good example of this trend. Likewise, the application

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of infrared spectrography to the study of chemical bonds of intermediate energy values and the quantitative estimation of particular compounds is greatly advancing knowledge of the enzyme reactions on which living processes so largely depend. It becomes clear that the metabolism of proteins may be concerned with molecular structures of low energy to which absorption of high-frequency radio waves may be applied.

Of exceedingly rapid development has been the application of the measurement of nuclear radiation. Not only has it been necessary to develop new systems of measurement, most of them electronic in character, but it also has been requisite that special applications of these systems be developed for following chemical reactions in living tissues.

SPECIAL DIAGNOSTIC APPLICATIONS

As electronic knowledge advances, there is a steadily increasing number of applications of these techniques to the problems of recognition of disease entities. The outstanding example of such an application is the well-established medical specialty of roentgenology, historically the first of the applications of electronic techniques to medical diagnosis. Of similar import and of growing utilization is electrocardiography, wherein the sequence of action potentials during the contraction cycle of the heart muscle may give valuable information concerning functional and anatomic deviations of that organ. Increasing applications of techniques of radiation measurement to the problems of diagnosis also are being found. A good example is the measurement of the rate of uptake of iodine in the thyroid as a function of the basal metabolic rate. Microcurie quantities of Iodine 131, quantities too small for significant physiological effect, may serve not only to delineate thyroid tissue anatomically but also to indicate the metabolic level maintained by the patient.

SPECIAL THERAPEUTIC APPLICATIONS

In the history of the alleviation or cure of disease processes, the application of nuclear radiations in the treatment of cancer has been of outstanding importance. With the separation of radium and the recognition of its effects on living tissues, there followed a prolonged inquiry into the manner of employing this element in the treatment of cancer. The development of the X-ray tube soon brought a second mode of applying such radiant energy to this same profoundly perplexing galaxy of disease. There gradually became established the new specialty of radiology and the recognition of the fact that there are approaches other than surgery to this most difficult chapter of therapy.

The early roentgen-ray machines were of low energy, and for the therapy of deep cancers could not equal the gamma radiation of radium from large external sources or from small sources implanted within the tissues to be irradiated. With time, however, operating potentials have risen steadily, so that 250-kv X ray has been available as a therapeutic tool for many years and 1,000,000- and 2,000,000-volt machines are becoming relatively common.

With the development of accelerators, there has been new impetus to the study of the potentialities of high-energy radiation. The betatron and proton accelerators make possible avenues of approach to the therapy of cancer not hitherto available. Atomic reactors, both directly and indirectly, through radioactive substances which they may produce, are assuming greater prominence in the therapy of specific diseases.

In the applications of electronic techniques to the treatment of the sick, one also should mention diathermy and many of the activities included in the general term physical therapy.

CONTROL APPLICATIONS

As in industry generally, medicine makes extensive use of the principle of control through feedback. Not only may dose rate in radiation therapy be a controlled quantity, but the very circumstances of medical therapy and research may be a part of control systems most of which are in part or totally electronic in character.

OUTSTANDING AEC ACTIVITIES IN BIOLOGY AND MEDICINE INVOLVING ELECTRONIC SCIENCE

The Division of Biology and Medicine of the United States Atomic Energy Commission (AEC) supports a large research program both within the National Laboratories and in the major universities of the entire country. The individual projects form parts of a very broad and comprehensive research program in which the applications of special electronic techniques are seemingly endless but fall into the general categories which have been mentioned previously. In addition to the research program, the Division is responsible for the standards of health and radiation safety in the AEC plants and other components of its industrial system. Health physics, which means not only the appreciation of radiation hazards but also the development of devices to measure such hazards, constitutes a large part of the responsibility of the Division.

Here, moreover, there is an excellent demonstration of the fact that no branch of science has sharp boundaries. Not only are instruments for the detection and measurement of nuclear radiations required for medical purposes, but they are also essential to the physicist for his investigations and for the production plants and engineers of the Commission for process control and measurement of operational efficiency. To have such instrumental development going along parallel and duplicating lines in various portions of the Commission's activities would be a serious waste. Therefore, the Radiation Instruments Branch was established in the Division of Biology and Medicine. Its functions are to serve the Commission generally in the development of instruments to meet the needs wherever they occur.

Part of the philosophy of establishing such a Branch was that the manufacture of instruments should be conducted by commercial units outside the Commission. Their products would find a general market and thus reduce the ultimate cost of such equipment to the AEC. The function of this Branch has been, therefore, to stimulate instrument design for specific needs and to foster within the Commission and between it and industry generally the interchange

of technical information bearing upon these problems.

The activities of the atomic energy program have accelerated the development of a considerable number of special instruments devoted to the measurement of radiations of physiological importance. These fall into two general groups: one consists of instruments giving the sum total of radiation experienced over a span of time, while the other indicates the instantaneous rate at which radiation is being delivered. In the first category of integrating instruments are included such devices as film badges, where a silver-halide emulsion combined with appropriate filters is used to record the total dose of radiation received. These are particularly valuable in gamma- and X-ray fields. There similarly has been a steady development of small and large ionization chambers with special characteristics. Many of these are instruments designed to be carried on the person, and some of them are direct reading. Instruments of this character are particularly employed for measurement of gamma radiation, but compact ionization chambers are anticipated soon which will be particularly responsive to the biological effect of neutrons.

A third group of integrating instruments are the chemical dosimeters in which some specific molecular change is used as the measure of the radiation absorbed. Most of these dosimeters exhibit the changes in the form of color variation, but there are a few in which the alteration may be in physical characteristics such as electrical resistivity.

The dose-rate indicators involve a large variety of such instruments as Geiger counters, proportional counters, scintillation counters, and ionization chambers which can be made more or less discriminating with respect to alpha, beta, gamma, and neutron radiations. These are all electronic devices involving pulse-height discriminating and shaping circuits, and the scaling and counting networks with which electronics engineers are generally familiar.

FUTURE TRENDS AND NEEDS FOR ELECTRONIC SCIENCE IN MEDICINE

While future developments cannot be fully anticipated in this characteristically mercurial field of endeavor, certain specific needs and probable requirements can be foreseen at this time. It is inevitable that electronic devices will become of increasingly varied application in medicine. It may be assumed that they will be used by large numbers of people not primarily interested in the devices themselves. Many of the problems here are essentially those faced by the television industry and lead to the fundamental conclusion that electronic devices may be of any degree of complexity provided they are inherently reliable and trouble-free. Stability of operation and long life of components, therefore, is an essential objective in the future development of instruments for measuring radioactivity. The substitution of transistors for electron tubes in counters and scalers should be a field of persistent inquiry and labor. The improvement of components to minimize breakdown of resistors and capacitors should be a continuing program.

Closely related to durability is portability. Compactness of design and light weight combined with ruggedness to shock and vibration greatly increase the possibilities of utilization of electronic instruments and devices of all kinds. Increasing sensitivity and improvement in signal-to-noise ratio of detectors, amplifiers, and such circuitry is an ever-present need. For scintillation techniques to be fully useful, not only must there be persistent effort in the improvement of crystals as scintillators, but also in the design of practical photomultipliers of low-temperature coefficients and high-electron-multiplication efficiency.

It may be anticipated that within the next decade there will be a great expansion in the utilization of radioactive materials in many phases of science and industry. The successful employment of many of these new materials will depend upon the availability of stable, dependable, and accurate electronic systems for measurement and control.

In certain other fields one can foresee increasing requirements that are at present met either imperfectly or not at all. Among these are devices analogous to the infrared spectrometers, but operating in the spectral zone lying between the present ultrahigh-frequency radio band and the long infrared for the systematic study and analysis of low-energy bonds in organic substances. It is possible that the protein chemist, the virologist, and the immunologist will find some of the most fruitful techniques lying in this field.

As the forms of radiant energy employed in medicine increase in number and energy range, their full utilization will depend upon satisfactory means for measurement and control. Systems selectively responsive to particular neutron energy ranges are very much needed, as are energy-independent neutron-measuring devices which will interpret flux in terms of biological effectiveness.

The development of linear accelerators and cyclotrons that can produce beams of relatively heavy nuclei such as carbon may find special uses in time in the treatment of cancer and other diseases. The development of such devices involves electronic problems not entirely unique in character, but certainly differing in degree from those presently encountered. It also may be anticipated that there will be increasing utilization of the techniques of neutron diffraction in the study of substances of biological and medical importance, with particular reference to their molecular structure and intramolecular relationships.

Closely allied with these needs are those for neutron sources which are compact and dependable, but capable of yielding neutron beams of preselected energies in one series of cases while at the same time there are similar requirements for compact devices yielding neutron fluxes of appreciable magnitude over a considerable area.

SUMMARY

The role played by electronic techniques in medical research and in therapy of specific diseases is a rapidly accelerating one. There is good reason to believe that the present trend will continue for an indefinite span of time in the future. Among the requirements to be placed on that portion of the electronic industry primarily concerned with radiation instruments must be the progressive improvement of existing forms and the development of entirely new designs for purposes which are becoming apparent as nuclear science develops.

Transmission-Line Impedance and Efficiency

W. W. MACALPINE
MEMBER AIEE

FOR RADIO-FREQUENCY transmission lines the Smith chart is often employed in making impedance calculations. In some cases the standing-wave ratio is very high and the resistance cannot be read accurately on the chart. Means are shown herein for computing the resistance, while the chart is used for reactance.

There is developed also a precise equation for the power in a system. A simple formula results therefrom for the efficiency of a line with high standing-wave ratio. It is more accurate in such cases than the usual formula for efficiency. The accuracy of the impedance and efficiency formulas has been justified by design experience.

A transmission line with source and load is shown in Figure 1. When the VSWR (voltage standing-wave ratio) is high, the method for computing resistance is to determine the VSWR at the point where impedance is known. Then that at the other point is computed, and thence the resistance.

On a line with $Z_o=1/Y_o=R_o(1-jB_o/G_o)$, a load $Z=R+jX$ has normalized impedance, $r+jx=Z/Z_o=(1/R_o)[R-(B_o/G_o)X+jX]$, with sufficient accuracy for present purposes. B_o/G_o is often important when VSWR is high. The VSWR is $S=(1+x^2)/r$ provided $r+jx$ is in the "permitted region" of Figure 2. (The curve for 1-per-cent accuracy is satisfied roughly by $r<0.1|x+1/x|$ when $|x|>0.3$.)

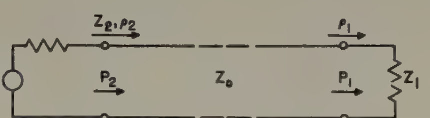

Figure 1. Transmission line with load and source

The VSWR at two points is related by $1/S_2=1/S_1+\theta\alpha/\beta$ (provided $S>6$) where θ is the electrical length in radians and α/β the attenuation in nepers per radian. Length θ is positive when point 2 is on the generator side of point 1.

All these combine into an over-all formula

$$R_2=R_1\frac{1+x_2^2}{1+x_1^2}+R_0(1+x_2^2)\left[\frac{\alpha}{\beta}\theta+\frac{B_o}{G_o}\left(\frac{x_2}{1+x_2^2}-\frac{x_1}{1+x_1^2}\right)\right] \qquad (1)$$

Note that R is the ohmic resistance and x the normalized reactance. Similar formulas can be written for admittances, and for impedance at one end and admittance at other. For example, when conductances G_2 and G_1 are related, R_0 is replaced by $1/R_0$, while x_2 becomes $-b_2$ and x_1 becomes $-b_1$.

Digest of paper 53-192, "Computation of Impedance and Efficiency of Transmission Line With High Standing-Wave Ratio," recommended by the AIEE Committee on Special Communications Applications and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Southern District Meeting, Louisville, Ky., April 22–24, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Area outside solid heart-shaped curve drawn on Smith chart is where formula is accurate to 1 per cent. Area outside dashed curve is where reciprocal of $r+jx$ lies in permitted region

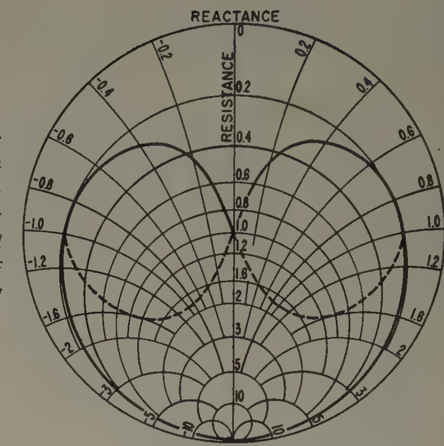

Figure 2. Permitted region for use of formula $S=(1+x^2)/r$

The power flowing in an a-c circuit is given by the real part of the product of the rms complex sinusoid voltage by the conjugate of the corresponding current. When these quantities are expressed in terms of ${}_fV$=voltage of the incident wave; characteristic admittance Y_o; and voltage reflection coefficient $\rho=|\rho|e^{j2\psi}$ there results

$$P={}_fV^2G_o[1-|\rho|^2+2|\rho|(B_o/G_o)\sin 2\psi] \qquad (2)$$

For lines with low VSWR the B_o/G_o term can be neglected and the usual formulas for power and efficiency of a radio-frequency transmission line result.

When VSWR is high and $r+jx$ is in the permitted region of Figure 2, the efficiency derived from equation 2 is

$$\eta=\frac{P_1}{P_2}=\frac{R_1}{R_2}\left(\frac{1+x_2^2}{1+x_1^2}\right) \qquad (3)$$

Note the similarity to the first terms of equation 1.

The equation for efficiency has a simple physical significance. Under the stipulated conditions, the current is approximately $I=I_{max}\sin\psi$ and $x=\cot\psi$. When these are substituted in $P=I^2R$ and it is noted that I_{max} is almost constant along the line at high VSWR, equation 3 results.

For lines with low VSWR, equation 2 yields the well-known equation

$$\eta=\frac{P_1}{P_2}=\frac{1-|\rho_1|^2}{1-|\rho_2|^2}e^{-2\alpha h} \qquad (4)$$

with maximum per-cent error

$$\pm 100(S_1-1/S_1)B_o/G_o$$

In the derivation of equations 3 and 4 from equation 2 there is used

$$S-1/S=4|\rho|/(1-|\rho|^2)$$

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Electrets

G. G. WISEMAN E. G. LINDEN

Electrets are discussed from the viewpoint of their measurement, materials from which they can be made, theories concerning their formation, and practical applications.

THE STRENGTH of an electret and its polarity are customarily expressed in terms of the charge density apparent at one of its surfaces as measured by an induction plate, see Figure 1. The electret's surface charge density D is taken to be approximately

$$D = -CV/A$$

where A is the area of the induction plate. For accurate measurements a guard ring is used.

Induction voltmeters of the rotating vane[1] or vibrating plate type[2] have been used to observe the charge of electrets, but measurements show that even the small air gap invariably present with such instruments is not an effective short circuit for the electret and consequently permits its more rapid decay. Moreover, the observed value of charge diminishes rapidly as the air gap increases.

For the present study, both manually operated and automatically recording induction-plate mechanisms were used. The apparatus for automatically recording the charge of several electrets at periodic intervals over long periods of time is described elsewhere.[3] Automatic measuring "stations" were built with sealed chambers to permit control of pressure and humidity. An entire station also can be inserted bodily into an oven for studies at controlled temperatures. For low-temperature studies, an automatic station was built in a Dewar flask and cooled with ice or solid carbon dioxide.

ELECTRET MATERIALS

STUDIES OF the electret effect in various materials are beclouded on the one hand by decay from conduction if the material is a poor insulator, and on the other hand by persistent molding and frictional charges if the material is a good insulator. Molding charges occurring during the preparation of electrets can be very troublesome, often persisting for months. They are frequently ignored which is probably the cause of "electrets" reportedly being formed with no electric field and the like. Almost any insulator, especially the high-resistance plastics, can acquire a persistent charge by means of a variety of treatments.

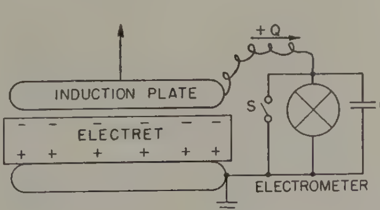

Figure 1. Switch S normally is closed. Charge measurements are taken by opening S and then lifting the induction plate free of the electret's field. The induced charge will charge the capacitance C of the system to a potential V which is read from the electrometer or vacuum-tube voltmeter

Another difficulty encountered in the study of electret materials is the indefinite composition of the sample. In the first place, the most common electret materials are carnauba wax, beeswax, sealing wax, and rosin which are themselves indefinite mixtures. For example, carnauba wax consists of carnaubic acid, an hydroxy acid, a dihydric alcohol, myricyl alcohol, ceryl alcohol, and a hydrocarbon. Secondly, impurities are likely to be formed during manufacture through overheating or chemical reaction. Previous work on presumably pure materials is scarce and is summarized in Table I. In studying this table it must be kept in mind that whether a material acquires a heterocharge or a homocharge depends not only upon the substance itself but also upon the electrical and thermal treatment to which it has been subjected.

Table I. Reported Electrets of Pure Substances

Substance	Observers	Charge
Sulphur	Mikola	Hetero
Abietic acid	Gemant	Hetero
Sodium chloride	Mikola	Homo
Calcium sulphate	Mikola	Homo
Paraffin	Theissèn	Neutral
Paraffin	Gemant	Neutral
Paraffin (overheated)	Mikola	Homo

Probably a better criterion of electret behavior than the sign of its initial or final charge is the ability of a properly treated specimen to exhibit a growth in the magnitude of its surface charge density under ideal (short-circuited) conditions. Even when subjected to electrical and thermal conditions advantageous to electret formation some substances acquire little or no charge or acquire a charge which merely decays to zero; examples of these substances are listed in Table II.

Other substances can be made to yield typical electret behavior (a charge reversal) or at least substantial growth in the magnitude of their charge. Examples are cited in Table III.

Polyvinyl acetate (Gelva V-7) forms electrets which have a strong surface charge, and an especially rapid recovery after damaging treatment. Only time will tell whether they are as permanent as carnauba wax electrets.

Revised text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953, and recommended for publication by the Subcommittee on Energy Sources of the AIEE Committee on Basic Sciences.

G. G. Wiseman is with the department of physics and astronomy, University of Kansas, Lawrence, Kans., and **E. G. Linden** is with the Squier Signal Laboratory, Fort Monmouth, N. J.

This work is supported by the Squier Signal Laboratory.

Table II. Substances Showing Only a Decaying Charge*

4-Acetoaminodiphenyl	Phenol Formaldehyde Casting Resin
Allyl Type Casting Resin	Polystyrene
Cellulose Acetate	Polytetrafluoroethylene (Teflon Sheet)
Cellulose Nitrate	Polyethylene
Ethyl Cellulose	Polyvinyl Acetate (Gelva V-1 1/2)
Glass (Window)	Polyvinyl Acetate (Gelva V-60)
Glyptal Varnish	Stearanalid (Emory A-805-R)
Naugatuk Vibrin X-1047	Urea Formaldehyde Casting Compound
Nylon Film (from solution)	Zophar Q322
Paraffin	Zophar Q461

Table III. Substances Giving a Charge Reversal or a Growth of Charge Indicating Electret Properties*

Biphenyl	P-hydroxydiphenyl
Carnauba Wax	P-methoxydiphenyl
Cerese AAA (Sacony-Vacuum)	Polyester (Plasticast B)
Glass (Pyrex)	Polymethylmethacrylate (Plexiglas)
Mitchell-Rand 3738	Polyvinyl Acetate (Gelva V-7)
Mitchell-Rand 3784	Sugar
National Coil Seal	Sulphur
Palmitic Acid	Zophar 1539
P-bromodiphenyl	

Most observers report a maximum electret charge density of about 3×10^{-9} coulomb per square centimeter. This limit is undoubtedly imposed by the electric breakdown strength of air at atmospheric pressure. Since the electric breakdown strength of air increases with increased pressure, strong electrets stored at pressures higher than atmospheric attain charges considerably greater than 3×10^{-4} coulomb per square centimeter, whereas exposure of electrets to pressures below atmospheric reduces their maximum attainable charge density.[4] One of the present authors has measured carnauba-paraffin electrets in air at pressures up to 5.6 atmospheres. At this pressure the maximum charge density attained by these electrets is limited by the maximum field that can be applied to the heated mixture during manufacture. In the same study it was shown that at very low pressures where the electric breakdown strength of air begins to increase with decreasing pressure, the attainable electret strength also increases.

THEORIES OF ELECTRET FORMATION

In spite of the fact that about 50 papers on electrets have appeared during the last 33 years and the fact that electrets have found practical applications, the mechanisms by which they gain and lose their charge still are not well understood.[5]

A satisfactory theory of electrets must account for several salient characteristics: (1) the spontaneous charge reversal, (2) the permanence and recoverability of the homocharge, (3) the apparent volume distribution of charge, (4) the specificity of the effect for various substances, and (5) the magnitude of the surface charge density. The theory is required to account for the observed phenomena in terms of reasonable electrical processes.

At the outset, it is well to bear in mind inherent limitations in the method of measurement of this electrostatic system; one cannot tell whether the electret's charge consists of a volume polarization or the combined effects of volume and surface distributions of charge. For example, as Swann has pointed out,[6] the diminution of an electret's field with distance is due to its finite size and not to its charge configuration alone. To find the internal structure of the electret one either must make internal measurements or else make internal changes by heating, irradiation, and the like and then interpret the results accordingly.

Various mechanisms whereby volume and surface charges are produced in dielectrics are well known. Those seriously considered as contributing to electret formation are

1. Ion migration. Ions which migrate under the influence of the manufacturing field give rise to a space charge which becomes frozen in when the electret solidifies.
2. Orientation of polar molecules. Electric dipoles tend to align themselves with the electric field while the electret is in the fluid or near-fluid state. The alignment becomes frozen in when the electret solidifies.
3. Microscopical heterogeneity. Maxwell has shown that charges collect at the interfaces of an inhomogeneous dielectric when it is subjected to an electric field. The decay rate of the resulting charges depends upon the conductivity which is considerably lowered when the electret is cooled.
4. Pyroelectricity and piezoelectricity. The manufacturing field can produce crystalline orientation in electrets and the cooling process can set up severe strains in the material. The result may produce a pyroelectric or piezoelectric charge.
5. Interfacial conduction. During manufacture, an intense field occurs at the interfaces between the dielectric and the electrodes. This field may become large enough to cause a conduction of charge across the interfaces. This charge is trapped in the surface of the electret.

One of the first theories of electrets was suggested by Adams[7] who proposed that the electret charges were due to a pyroelectric effect with an extremely long lifetime. Gemant[8] was the first to observe that the charge–time curves strongly suggest the interplay of two competing effects: one producing the heterocharge, the other producing the homocharge. He postulated a piezoelectric effect as the homocharge mechanism and frozen-in, ionic migration as the heterocharge. Both Adams' and Gemant's accounts of the homocharge require that the electret be crystalline and piezoelectric. Several attempts have been made to observe piezoelectricity in electrets; the consensus is that they are not piezoelectric and these theories are not now generally accepted. Although X-ray diffraction patterns of electrets often reveal crystalline orientation,[9–12] the present study has verified the observation that the crystalline orientation which is apparent in X-ray diffraction patterns is not a necessary condition for electret formation.

Swann[6] has given a mathematical treatment of an electret consisting of a distribution of polarization which decays slowly with time and a distribution of surface and volume charge which disappears according to ohmic conductivity having no relation to the decay of the polarization.

The three heterocharge mechanisms (ion migration, dipole orientation, and Maxwell's microscopical hetero-

* Most of the data of Tables II and III were obtained by F. R. Rollins and G. R. Feaster of these laboratories.

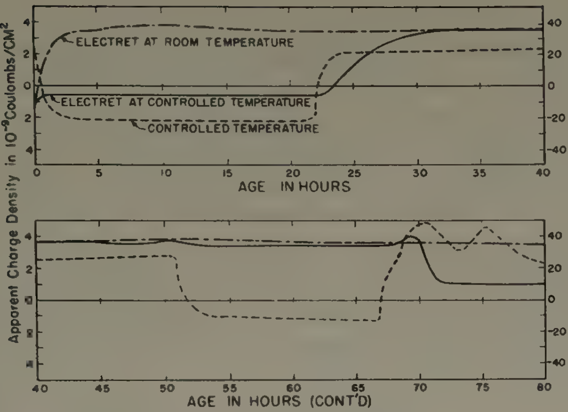

Figure 2. Graphs showing that an electret's reversal is arrested by cooling. Values are replotted from an automatic charge recorder. Electrets were prepared from polyvinyl acetate (Gelva V-7). The homocharge is positive

geneities) are the same mechanisms which are used to explain ordinary dielectric absorption (residual charge). Gross,[13,14] after careful simultaneous measurements of the external current and the rate of change of the electrets' charge, concluded that the heterocharge consists of dielectric absorption which is frozen in throughout the volume of the electret and that the homocharge consists of a persistent ionic surface charge deposited by electrical breakdown of the interface between the electrode and the dielectric during manufacture. By a separate experiment he has demonstrated that such interfacial conduction and the resulting persistent charges do occur with polystyrene, a nonabsorptive dielectric.[15] The present investigation has verified his results for polystyrene and shown that the same mechanism is operative with three absorptive dielectrics as well: carnauba wax, paraffin (very slightly absorptive), and polymethylmethacrylate (Plexiglas).

While the electret is being stored short-circuited, the situation is as follows. The net surface charge (homocharge minus heterocharge) induces a charge of opposite sign on the adjacent electrodes. The field in the gaps between the electrodes and the electret is strong and the field in the interior of the electret is weak. The homocharge and the charge on the adjacent electrode are bound to each other across the interface, but they do not combine by conduction because of a large potential barrier at the interface. The homocharge does not decay by volume conduction because of the small field in the interior.

According to this picture, the charge reversal of electrets occurs because the decay of the frozen-in volume polarization is more rapid than the decay of the surface charge. If the decay of the heterocharge is thermally induced, electrets should not undergo their usual reversal at low temperatures. To test this hypothesis "twin" electrets were made; one was enclosed and measured in a desiccated Dewar flask cooled with solid carbon dioxide and the other, used as a control, was measured in a sealed and desiccated chamber at room temperature. The results are shown in Figure 2. The electret which was maintained at room temperature reversed its charge in typical electret fashion whereas the reversal of the test electret was arrested by cooling. The heterocharge remained solidly frozen in as long as the electret was kept cold but as soon as it was warmed a normal reversal occurred. Cooling the electret after reversal (at 51 hours in Figure 2) produced no definite effect since cooling merely preserves the static conditions. Subsequent severe reheating (beginning at 67 hours) first produced a transient charge increase which is evidently due to the decay of some residual heterocharge. Prolonged heating caused the eventual destruction of the electret's homocharge. These observations give additional support to the belief that the heterocharge consists of a frozen-in volume polarization and that the homocharge is due to a different mechanism.

Although the Gross theory of electrets as presented here is the most satisfactory advanced so far, several problems remain:

1. The theory does not explain the specificity of the effect for various substances; for example, some substances show only heterocharges whereas the theory would predict that all absorptive insulators should acquire a homocharge at high manufacturing fields. It is possible that the experiments rather than the theory err on this point.
2. The relative importance of the various heterocharge mechanisms is not clearly known. For example, electrets can be made both from sulphur which presumably contains no ions or permanent dipoles and from Plexiglas which is presumably homogeneous. Perhaps different effects are predominant in different substances.
3. The processes which occur in the interfaces between the electrodes and the dielectric during the formation of the homocharge are not clearly known. Electrets can be formed with an air gap present or they can be formed with the fluid dielectric actually wetting the electrodes.
4. The nature of the large potential barrier at the interface and its dependence upon temperature are not clear.
5. The origin and nature of the molding charges present on electrets made from molten material are not understood well.

PRACTICAL APPLICATIONS

Even though the theory of electrets is incomplete, they have been used in a number of practical applications. However, misconceptions of electrets have led to some impractical proposals.

The first of these misconceptions seems to arise from the experiment of Eguchi in which the electret apparently delivers an unlimited number of good-sized sparks. In this experiment a spark gap is inserted in the wire which normally connects the upper and lower electrodes. When the upper electrode is lifted, the charge which has been induced on it during the previous short circuit will flow across the gap producing a spark. The experiment can be repeated an indefinite number of times provided that the electrodes are short-circuited before lifting the upper electrode each time. From this experiment one of two inferences sometimes is made: (1) that the electret is a source of current or (2) that some cause other than the permanent electret charge (such as frictional electricity) is the true origin of the spark. Of course neither inference

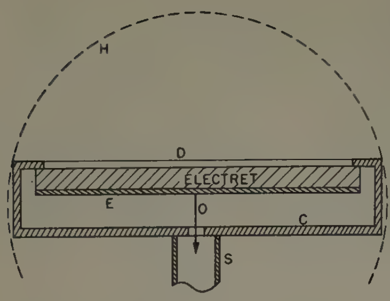

Figure 3. Schematic cross section of electret microphone

C—case; D—diaphragm; E—back electrode; H—wire housing; O—output lead to amplifier; S—shield

is true; the experiment is nothing more than the classic electrophorus experiment of Volta with Volta's frictionally charged wax surface being replaced by the electret. In neither of these experiments does the dielectric furnish any charge or any energy. The charge is furnished by induction when the plates are short-circuited and the energy is furnished by the experimenter when he lifts the electrode.

A second misconception is based on the idea that an electret possesses a definite potential difference between its surfaces. For practical purposes the electret is best regarded as a purely electrostatic system of charges and the potential difference between its faces is determined not only by its own charge configuration but also by the presence of nearby conductors and charges. When the electret is short-circuited, the potential difference between its surfaces is practically zero.

Thus it can be said that electrets cannot be used to furnish charge, energy, or (under most conditions) a definite potential difference. For example, they cannot be used like batteries for a grid bias; neither can they be used to furnish a field in the presence of ions. In this connection, the proposal is sometimes made that neutralization by ion collection be prevented by enclosing the electret in a plastic shield, and so forth, but of course ions would collect on the shield as well as on an exposed electret and with the same neutralizing effect. Fortunately the magnet does not have the analogous disadvantage of collecting free magnetic poles, since none exist.

In spite of these limitations the electret has found use in several practical applications and other uses probably will be devised.

Two types of electrometers and an electrostatic vibration voltmeter have been built and tested by Gemant in which electrets are used to furnish the necessary electrostatic field.[16, 17] These instruments compare favorably in sensitivity with conventional instruments, although over long periods the electrets which have not been short-circuited will deteriorate. Their advantage lies in their small size and weight.

Electret microphones[18] have been built by many experimenters including amateur radio operators. A microphone was built during the present investigation for display at the Squier Signal Laboratory. See Figure 3.† The electret microphone is similar to the capacitor microphone; its output voltage depends upon the capacitance of its load and a preamplifier is desirable for this reason. It suffers from additional disadvantages: vulnerability to ionizing radiations and deterioration with time. Despite these disadvantages, the Japanese used them during World War II. It is felt that with better electret materials and improved designs, electret microphones may find wider use; they can be made very light and compact and they require few enough critical materials to be expendable.

An electret earphone has been built. Like the electret microphone, it can be simply and cheaply made. Its input impedance is high.

Radiation dosimeters of several types employing electrets also have been built and tested.

† This microphone was built by F. W. Prosser.

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Air Force Seeks Engineers

The Overseas Employment Branch of the United States Air Force has announced that there are vacancies overseas for several qualified engineers in various fields. The critical need for engineers to help operate and maintain air bases in many foreign countries has created a demand for men who are fully qualified in their fields. Quarters in most cases are either furnished free of charge or an allowance to cover cost of rental is provided.

Placement officers of the Overseas Employment Branch of the Air Force Headquarters may be contacted at Overseas Employment Branch, Department of the Air Force, 11 West Monument Street, Dayton, Ohio.

Multistation Supervisory Control

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THE USE OF supervisory control by power companies for the operation of remote stations has increased greatly during the past 10 years. Power-line carrier current is being used on large power systems to make possible the control of widely separated stations from a common point. This type of channel has made possible the control of stations at distances as great as 200 miles.

As an example, the Kansas Power and Light Company at Topeka, Kans., wanted to control five stations on a system shown schematically in Figure 1.

The only carrier frequency available for supervisory control was 74 kc. This immediately eliminated duplex carrier which would require ten carrier frequencies (one in each direction between each substation and the dispatching station). It also eliminated the system which would use a common carrier frequency from the dispatching station to all the substations for control, with a separate carrier frequency from each substation to the dispatching station for indications, since this would require six carrier frequencies.

Since the same carrier frequency will be transmitted from all stations, new stations may be added to the supervisory system without modifying the existing equipment.

A contact of a relay in the automatic volume control circuit also is being used to lock out the supervisory at any given station while a carrier signal is received from another station.

In going to single-frequency carrier for supervisory operation, it was evident that the following features of Supertrol supervisory had to be sacrificed in favor of greater economy:

1. Supervisory indications from each of the substations cannot be received instantaneously as the operation is being performed, but must be "remembered" and reported in when the channel is clear. This, however, can be tolerated since an indication cycle is completed in less than 10 seconds.

2. Supervisory alarm indications from each of the substations cannot be reported in to the dispatching station independent of other stations.

3. If telemetering is added at a future date, any telemetering in progress will be interrupted by supervisory operation or telephone communication from the dispatch station and supervisory indications and telephone communication from another substation.

The Supertrol supervisory for multistation control over single-frequency carrier as supplied to the Kansas Power and Light Company at Topeka uses sequence of four audio tones to perform operations. These four tones are made up

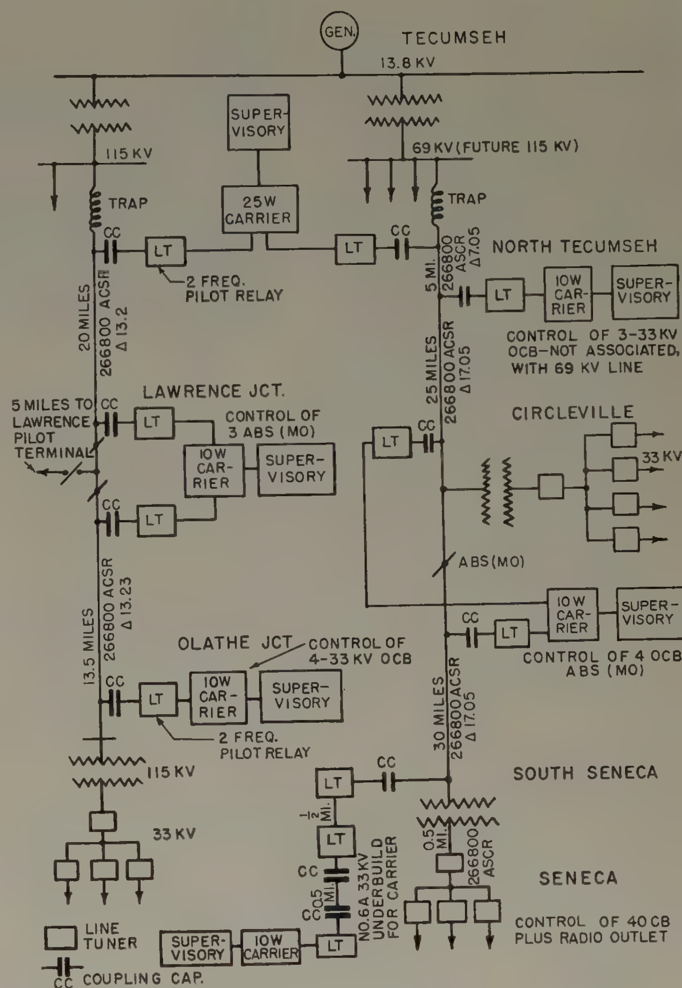

Figure 1. Single-line diagram of Kansas Power and Light Supertrol system

from five frequencies. A single tone may be repeated in a sequence but never follows itself. Some 320 operations may be performed by using five frequencies in a 4-signal sequence, and by a slight modification a 5-signal sequence may be used to perform 1,280 operations. These operations may be divided among any number of stations in any proportion.

When the carrier channel is not being used, any one of the remote supervisory units may report in to the dispatching station. The carrier transmitter is first keyed and the receivers at all other stations respond. A relay in the automatic volume control circuit of the carrier receiver will lock out its supervisory and carrier transmitters. A series of pulses will be transmitted to the dispatching station to identify the substation reporting in. All positions at this substation then will be checked at the rate of six to eight points per second. After this the identification of the station again will be checked.

Digest of paper **53-190**, "Multistation Supervisory Control Over Single-Frequency Carrier," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Southern District Meeting, Louisville, Ky., April 22–24, 1953. Not scheduled for publication in AIEE *Transactions*.

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Communications Synchronizing Systems

F. T. TURNER

Properly designed synchronizing systems are capable of maintaining synchronism to very high orders of accuracy even in the presence of what appear to be very high noise levels. By re-examining conventional synchronizing systems in the light of frequency-modulation communication theory, it is shown how this is achieved. The synchronizing system is also discussed as a servomechanism.

WHERE SPECIAL waveforms of synchronized signal are required, these usually are known in advance, and their transmission would be redundant. Since any desired waveshape may be derived from a sine wave by appropriate clipping and shaping circuits, the synchronizing signal can be transmitted in the form requiring the least bandwidth, that is, a sine wave. Where more convenient, the desired waveshape may be transmitted, but the added bandwidth required is of no significance for the purpose of synchronization.

If the transmitter were absolutely stable as to frequency, at least within the limits of the required accuracy, a local source of equal stability could supply synchronization and the transmission of this information would be redundant. It is only in those cases where the transmitter is expected to vary in frequency that synchronizing information must be transmitted.

The synchronizing signal, therefore, is a carrier which is modulated with certain intelligence; namely, the variations in frequency at the transmitter. The synchronizing signal is, therefore, a frequency-modulated carrier. Various methods are used to obtain the required local signal from this carrier.

In the simplest case, the local signal is obtained from the transmitted signal either directly or by injection synchronization of a local oscillator or multivibrator.

Where noise in the transmission path is negligible, this system may be quite satisfactory. However if noise is present at a significant level, the accuracy of synchronism may be degraded. The signal/noise ratio may be improved to any desired extent by inserting a band-pass filter in the signal path, provided that the filter is still wide enough to pass the maximum excursions of transmitter frequency. Since in many cases the transmitter frequency deviation, the noise level, or the required accuracy may not permit this solution, recourse must be made to other methods.

Analysis of many synchronizing systems which have demonstrated their ability to operate through high noise levels shows that they may be represented in their basic elements by Figure 1.

The incoming synchronizing signal is applied to a phase-sensitive detector together with the output of the local oscillator. At the output of the detector there appears a voltage which is a function of the phase angle between the two applied voltages, being zero at ± 90 degrees and positive or negative at other angles. This voltage is applied to a frequency-controlling circuit of the local oscillator in such manner as to reduce to a low value any shift in phase between the two input voltages.

It is customary in most cases to integrate the output of the phase-sensitive detector over a number of cycles of the synchronizing signal, in order to average out the effect of small random variations in the signal, usually resulting from noise. Such synchronizing systems have proved capable of maintaining synchronism to a very high order of accuracy through very high noise levels, often when the other intelligence is lost entirely for practical purposes.

A re-examination of the elements of the system, using concepts commonly encountered in frequency-modulation communication, leads to a better understanding of the properties of synchronizing circuits.

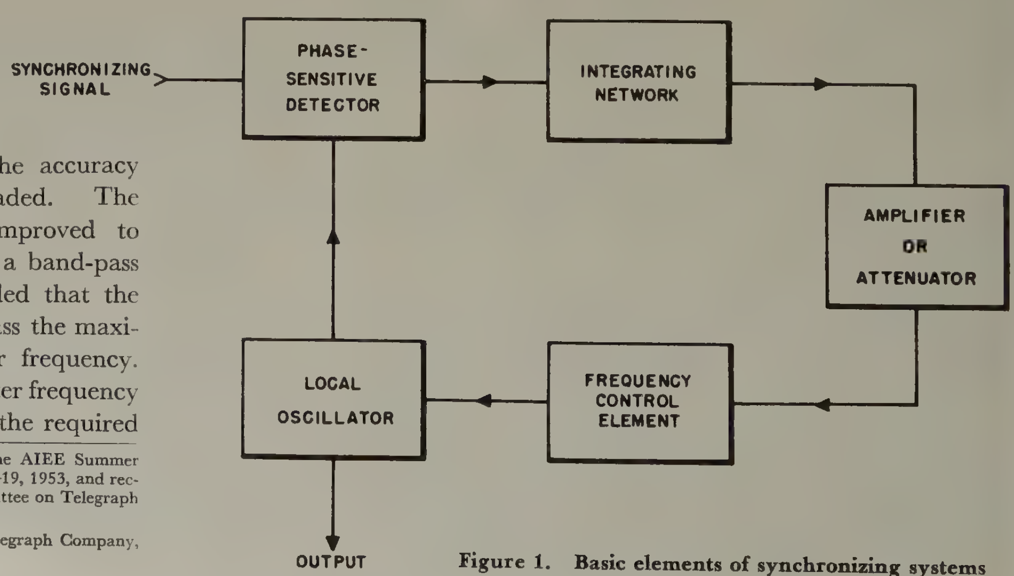

Figure 1. Basic elements of synchronizing systems

Full text of a conference paper presented at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953, and recommended for publication by the AIEE Committee on Telegraph Systems.

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When employed in combination with the controlled local oscillator, the output of the phase-sensitive detector will have a constant value for a constant frequency deviation of a given polarity for a frequency lower than normal and of opposite polarity for a frequency higher than normal. The combination is, therefore, in effect a frequency-modulation detector.

The output voltage of the detector is proportional to the magnitude of the frequency swing of the synchronizing signal, and contains components of frequencies equal to the modulating frequencies. The "integrating" circuit commonly employed may be considered as a form of low-pass filter, imposing a restriction on the over-all synchronizing signal bandwidth as measured at the output terminals of the phase-sensitive detector. It is obvious that this circuit cannot restrict the bandwidth to less than that required to pass the highest modulating frequency (that is, rate-of-change of frequency) without impairing the ability of the receiver to follow the variations of the transmitter. Its only value can be to reduce the amplitude of variations in the signal caused by noise components of frequencies outside the band required for transmission of the synchronizing signal, where the bandwidth at the input terminals of the detector is not restricted already to the minimum required.

In the practical case, it is easier to obtain this bandwidth restriction in this manner than by the use of band-pass filters ahead of the discriminator. Some improvement in performance might be obtained by redesign of the integrating circuits as low-pass filters, although the extremely low frequencies usually involved might make the construction of such filters impracticable.

Noise components or interference outside this band will produce output frequencies lying above the cut-off frequency of the integrating network and hence are of no concern. Noise components within this band will produce effective phase modulation. It appears, then, that noise is still capable of affecting synchronization. Since a true phase-sensitive detector, one form of which is shown in Figure 2, is not directly sensitive to noise, or to amplitude modulation of the received signal provided that it does not fall below that of the signal from the local oscillator, it is only the phase modulation produced by the noise which is of significance. The phase modulation is given to a first approximation as

$$\sin^{-1}\frac{E_i}{E_s} \tag{1}$$

where E_i=interfering voltage and E_s=signal voltage.

It is also of interest to note that we have a form of servomechanism applied to the local oscillator. Assuming the transmitter to be constant in frequency for some period of time, any tendency of the local oscillator to drift produces an error voltage which is applied to reduce the drift. The local oscillator, therefore, is stabilized by a factor $S=1+Y$, where Y is the loop-transfer function of the servomechanism.

In some special applications it is desired that synchronism be maintained during a period of circuit interruption. In these cases a more stable local oscillator is employed, but new difficulties may be introduced thereby. If there

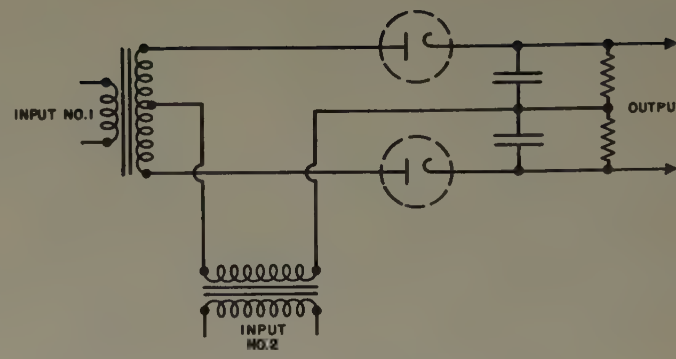

Figure 2. Phase-sensitive detector

is any significant lag in the response of the oscillator to a change in control voltage, another reactive element is introduced into the loop transfer function Y, and a finite upper limit for Y is established beyond which the system becomes unstable. The accuracy with which the local oscillator follows the variations of the transmitter is determined by Y, and may be impaired if it is necessary to reduce Y to achieve stability.

Servomechanism practice employs differentiating circuits in the loop to compensate for reactive components elsewhere, but such circuits are seen to be of opposite characteristics to the integrating circuits referred to previously and may increase the susceptibility of the system to noise.

In designing a synchronizing system, it is desirable to weigh carefully any requirement for maintenance of synchronization during a period of circuit interruption, and to consider if it may not be met as well by rapid stable re-establishment of synchronism at the end of the interruption.

Facsimile transmission is a typical case in which synchronizing problems arise and will serve to demonstrate the application of the statements made earlier.

A typical facsimile system operating at 180 rpm with certain standards of definition will require a band 2,400 cycles wide for its transmission.

It is often the case that the transmitter is operated by or synchronized with commercial a-c power. A study of a typical commercial power source has shown that the variation of frequency ordinarily encountered in this source will be of the order of 0.2 cycle and the rate-of-change of frequency will be of the order of 0.024 cycle per second per second. Assuming that the synchronizing signal, however transmitted, will represent this source, then there is a signal which can be reduced to a carrier frequency of 60 cycles, a maximum excursion of ±0.2 cycle, and a maximum rate-of-change of frequency of 0.024 cycle per second per second. In frequency-modulation terminology the first two quantities correspond to the carrier, F, and the peak deviation, ΔF, respectively. The quantity dF/dt can be shown to be equivalent to a maximum modulating frequency, f, of 0.0191 cycle. Then

$$\frac{\Delta F}{f}=\frac{0.2}{0.0191}=10 \text{ approx.}=\beta \tag{2}$$

is the modulation index. Reference to a table of Bessel functions for $\beta=10$ shows that side-band pairs of order higher than 14 have amplitudes less than 1 per cent of

the carrier and can be neglected. Thus there is a bandwidth before detection of

$$2\times14\times0.0191=0.535 \text{ cycle} \quad (3)$$

The accuracy required for this type of service is of the order of 0.1 degree of revolution. This is 2 degrees of the 60-cycle driving voltage. The noise voltage capable of producing an error of this magnitude through equivalent phase modulation is E_s sin 2 degrees or 0.035 E_s. Expressed in decibels this is a S/N ratio of 29 decibels.

Thus an S/N ratio of 29 decibels in a band 0.535 cycle wide is needed. If random noise is assumed present at this level, the S/N ratio in the total band required for transmission of the facsimile signal will be

$$29-10\log_{10}(2{,}400/0.535)=29-36.5=-7.5 \text{ decibels} \quad (4)$$

Such a noise level would result in almost complete obliteration of the facsimile message.

The same combination of basic elements may be found in some television receivers for horizontal synchronization. A local oscillator operating at the horizontal sweep frequency supplies an input to a phase-sensitive detector. The other input is obtained from the horizontal synchronizing pulses. The resultant output is integrated and applied to a frequency control circuit on the local oscillator.[1, 2]

Another example of transmitted synchronization is found in automatic printing telegraph communication. A motor-driven sending commutator is controlled by a tuning-fork frequency standard of moderate stability. At the receiving end a saw-tooth wave is generated by auxiliary segments on the receiving commutator. A polar relay samples the saw-tooth wave at regular intervals under the control of the received signal. The samples thus obtained are integrated and applied to circuits for correcting the speed of the tuning fork at the receiving end. In this case, the sampling relay corresponds to the phase-sensitive detector of Figure 1. Its output in this case is not a cosine function of angle but may be made to approximate closely a linear function over quite a wide range.

In designing a system for synchronization by a transmitted signal, the first step is an analysis of the order of stability of the source. From this may be obtained the bandwidth required for transmission of the necessary information following methods given in any standard text on frequency-modulation communication theory.[3]

The same analysis also leads to a first-order approximation for the time constant of the integrating network, that is, that it be able to pass the highest rate-of-change substantially unattenuated. The requirement for accuracy then may be used to give the required signal-noise ratio in the band thus determined using equation 1.

The required accuracy also leads to a solution for the value of the servo loop transfer function Y as follows:
Let

A = frequency control constant in cycles per second per volt.
B = detector sensitivity in volts per degree, for angles near 90 degrees.
C = maximum deviation of transmitter frequency in cycles.
D = maximum deviation in cycles of local oscillator frequency in the absence of a controlling signal (local oscillator stability).
E = required accuracy in degrees.
K = a loop constant determined by the integrating network and attenuators or amplifiers as required. Then

$(C+D)/ABK$ must equal E or

$$(C+D)/E=ABK=Y \quad (5)$$

A, B, and especially K may be complex, and the product Y must satisfy the requirement for stability as discussed in servomechanism literature.

It is of interest to consider the requirements for establishment of synchronism on initial application of the synchronizing signal. Depending on the waveshapes applied to the phase detector, the output may be a cosine, linear, or discontinuous function of relative phase angle. When sine waves are applied, it is a cosine function, having a maximum absolute value at 0 ± 180 degrees of $57.3B$. If the transmitter and local oscillator may differ by a maximum of $C+D$ cycles prior to establishment of synchronism, then the voltage required at the terminals of the frequency-controlling element to correct the local oscillator is $(C+D)/A$ volts.

As shown, the peak output of the detector for sine-wave inputs is $57.3B$. Since this will be an alternating voltage of frequency $C+D$, a requirement can be established for K at $f=C+D$, relative to its value at $f=0$. If

$$57.3BK_{C+D}=\frac{C+D}{A_{C+D}} \quad (6)$$

then synchronism will be established.
from equation 5

$$K_o=\frac{C+D}{A_oBE} \quad (7)$$

from equation 6

$$K_{C+D}=\frac{C+D}{57.3BA_{C+D}} \quad (8)$$

then

$$\frac{K_{C+D}}{K_o}=\frac{C+D}{5.73BA_{C+D}}\div\frac{C+D}{A_oBE}=\frac{A_oE}{57.3A_{C+D}} \quad (9)$$

If $A_o/A_{C+D}=1$ then $K_{C+D}/K_o=E/57.3$. It will be seen that where the required accuracy is much less than one radian (usually the case), the transmission of the integrating network, which in most cases is the chief complex component of K, may be allowed to drop rapidly for frequencies higher than that representing the maximum rate-of-change of transmitter frequency, as long as

$$K_{C+D}=\frac{K_oE}{57.3}$$

The requirement $A_o/A_{C+D}=1$ implies that the imaginary component of A is negligible over the frequency range of interest. Often this is not true when mechanical devices are a part of the frequency-controlling means.

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Diesel-Electric Locomotive Ground Relays

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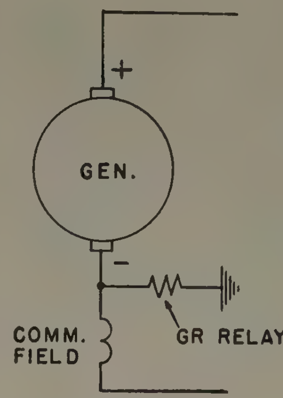
THE GROUND RELAY as used on a diesel-electric locomotive provides a number of important protective features. It was originally applied to furnish flashover protection, but has become useful in connection with other functions so that it now provides protection on a diesel-electric locomotive for:

1. Armature grounds in either the main generator or traction motors.
2. Accidental power circuit grounds.
3. High-resistance creepage grounds, such as those caused by moisture and dirt.
4. Flashover protection for the generator, motors, and contactors.
5. Ground protection during dynamic braking.
6. Ground protection during engine starting.



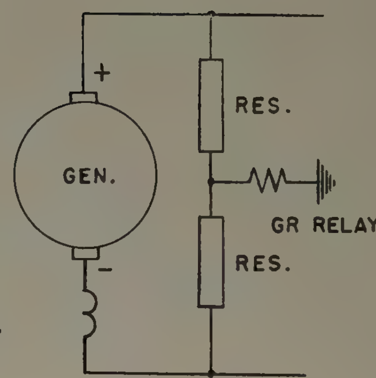


Figure 1 (left). Ground relay connected on negative side of generator. Figure 2 (right). Resistance bridge connection for ground relay

Two main types of ground relay connections are in common use. With one type the coil of the relay is connected between the power circuit negative and ground, as shown in Figure 1. With the other type, the relay coil is connected to the mid-point of a bridge across the power circuits, as shown in Figure 2. This bridge in some cases consists of resistors and in other cases involves reactance and resistance. Brief comments on each of these types of connections with respect to the functions listed above are

1. With an armature ground, a negative-connected relay has applied to it a fully displaced a-c wave or undulating d-c wave. Under the same conditions, a bridge-connected relay is subjected to an alternating voltage. Either type of relay provides good protection.

2. A negative-connected relay works well on a positive circuit ground. On a ground that occurs on a negative of the system, there is a tendency to short-circuit the ground relay coil. However, by connecting the relay between the negative of the generator armature and the generator commutating field, the reactive voltage generated by load changes in this field will be adequate to produce relay operation. A bridge-connected relay detects this type of ground properly.

3. Leakage or creepage grounds will be detected with either type of relay. The relays should not be so sensitive as to cause small leakages to interfere with locomotive operation. On the other hand, it should be appreciated that all of the leakage current does not normally go through the relay. Care, therefore, must be taken to arrive at a compromise setting which will not interfere unnecessarily with locomotive operation but will not permit leakage currents of such high values as to cause permanent damage to the insulation surfaces.

4. The negative-connected relay will provide good flashover protection. Commutator flashovers go to ground and establish a ground potential midway between the terminals of the machine. A resistance bridge connection is not reliable under these circumstances. A reactance resistance bridge in all probability will displace the potential of the bridge end of a ground relay coil sufficiently to provide good operation.

5. There is a difference in practice in the industry with respect to ground relay protection during dynamic braking. Without ground relay protection there is no way of clearing a motor flashover. As the motors may be operated at relatively high voltage during braking, this becomes a serious consideration.

From this brief discussion it should appear obvious that any change in the operating conditions of a ground relay either as to circuit, operating voltage, or current, should be considered with respect to all of the functions performed by the relay.

Some types of faults, such as flashover, should be cleared promptly in order to limit damage. The ground relay is usually arranged to de-energize the generator by opening its shunt field circuit. Particular care should be exercised to insure fast handling of this circuit without producing voltages which would be harmful to the field.

Moisture leakage conditions, in general, have been troublesome in that ground relay operation has interfered unnecessarily with locomotive operation. A program is underway to investigate this type of generalized locomotive leakage with the object of improving power circuit insulation and of determining the relative magnitudes of leakage currents with respect to the possibility of tracking over the surface of the insulation.

Digest of paper 53-77, "Diesel-Electric Locomotive Ground Relays," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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The Unit Dielectric Strength of Oil

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IN DESIGNING FOR optimum dimensions and shapes in oil circuit breakers and other oil-insulated equipment, it has been found advantageous to determine, by means of the electrolytic field analyzer, the distribution and magnitudes of the electrical stresses which exist as a result of the application of high voltage. To make use of this information, the designer must know with engineering accuracy the unit dielectric strength of the oil; that is, the maximum electrical stress that the oil will withstand anywhere in the gap without puncture. The best generally available data on this subject have consisted of a set of empirical curves published by F. W. Peek in 1915 for oil adjacent to spheres and cylinders of different radii. The fundamental reason that oil would withstand much higher unit electrical stress when adjacent to some shapes than to others has not been understood. As a consequence, when faced with a practical shape which was neither a precise sphere nor a precise cylinder, one has not known what value of dielectric strength to use, within a range of two or three to one.

Considerable light is thrown on the physical picture involved by one simple pair of tests on classical shapes. Peek presented breakdown data for a parallel disk gap with rounded edges and for a concentric cylinder gap in which the inner and outer diameters were about 11 and 13 centimeters, respectively. For all practical purposes both gaps imposed uniform parallel-plane fields, and both would have broken down at essentially the same electrical stress in air. Yet in oil, with the disk electrodes, the maximum stress at breakdown was about 100 kv/centimeter; and with the concentric-cylinder electrodes, the maximum stress was in the order of 50 kv/centimeter. The salient factor which differs between the disks and the cylinders is that many times the volume of oil is under stress in the cylindrical gap. The hypothesis offered in this article is that the volume of the oil under stress is one of the primary factors which determine the dielectric strength of commercial oil of controlled quality. The reason is basically statistical, and depends upon the fact that commercial oil in small volumes exhibits very large statistical variations in successive breakdown values for the same oil and in the same gap. Breakdown will occur at the weakest spot in the dielectric under relatively high stress. If in another gap a greater volume of oil is stressed to the same degree, it is probable that a still weaker spot will be present and that failure will occur at lower voltage.

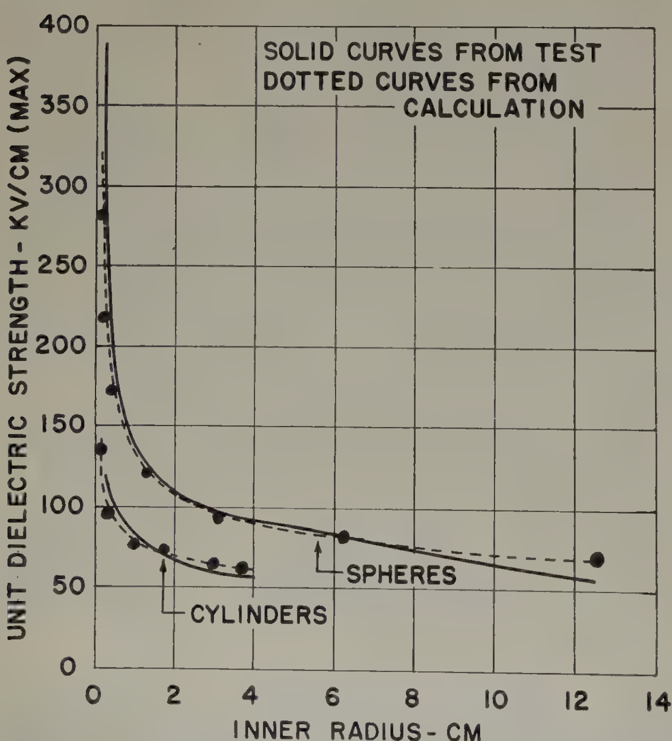

Figure 1. Comparison of calculated and test curves of unit dielectric strength for isolated spheres and cylinders

Mathematical solution can be found for this problem if the statistical distribution of the test data for unit volume is assumed to be normal. If both the average dielectric strength and the standard deviation are known for some volume of oil, this volume may be defined as unity. Then, the mathematics yields corresponding values of average dielectric strength and standard deviation for electrode configurations in which a number (either greater or less than one) of unit volumes of oil are stressed simultaneously. This analysis is applicable to many "weakest link" problems in which failure of any one of a number of units constitutes failure of the system.

As a quantitative check on the theory, points for several of the primary empirical curves describing fundamental dielectric properties of oil at 60 cycles have been calculated. Figure 1 shows two of these functions. The curves are from test data, and the points are from statistical calculation. Considering that the very existence of the theory depends upon extreme random variations, the accuracy with which the mathematical analyses check test data is most gratifying.

The theory as presented is in no sense considered to be complete. Additional factors must be established to explain anomalies which exist. For this reason, when investigating a new dielectric structure, it is desirable to base calculations on a reference structure which is not too dissimilar and one for which performance characteristics are known.

Digest of paper 53-131, "A Fundamental Factor Controlling the Unit Dielectric Strength of Oil," recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Analysis of Losses in Loop-Interconnected Systems

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IN ORDER TO account for losses in interconnected system operation, an accurate method has been devised to determine readily system transmission losses for all normal variations which might be encountered in the parallel or looped operation of several interconnected companies.

This article presents a method whereby loss formulas representing any desired interconnection of individual companies may be determined by interconnecting the loss formulas for each individual company.[1] This method makes it possible to study a group of interconnected companies which could not be represented simultaneously on the network analyzer.

The first four steps in the procedure in determining transmission loss formulas for parallel interconnected systems are the same as used for radial interconnected systems:[2]

1. Separate loss formulas are obtained for each individual system by known methods[3,4] and include terms for each generator and each interconnection point.
2. The loss formulas then are transformed to express the individual tie-line flows in terms of circulating flows and interchanges between systems.
3. The separate loss formulas are then mathematically interconnected to obtain one total transmission loss formula for the entire interconnected system that includes terms for all the generators, circulating flows, and interchanges between companies.
4. The terms for the circulating flows are eliminated from the total transmission loss formula.

The extension of the preceding method to a loop-interconnected system involves establishing the paths of excess and sneak power flow as indicated in Figure 1. In radial interconnected systems, interchange between companies can be specified. However, in loop-interconnected systems, the interchanges between companies such as $P_{T,OI}$ are generally unknown; but a company's excess power, defined as the sum of the deliveries to the other companies, can be specified. In general, for n interconnected companies, $n-1$ excess powers can be specified. Then as many sneak powers as necessary may be defined so that all interchanges may be expressed in terms of excess and sneak powers. A simple example is given in Figure 1, which is a schematic representation of the Indiana and Ohio operating divisions of the American Gas and Electric Company, interconnected directly and through external companies. The interchange powers can be expressed as

$$P_{T,OI}=P_{\text{sneak}} \tag{1}$$

$$P_{T,EO}=P_{\text{sneak}}-P_{\text{excess},\,O} \tag{2}$$

$$P_{T,IE}=P_{\text{sneak}}+P_{\text{excess},\,I} \tag{3}$$

These expressions permit transformation of the total transmission loss formula, containing terms for all generators and interchanges, to a formula containing terms for all generators, the Indiana and Ohio excess powers, and the sneak power.

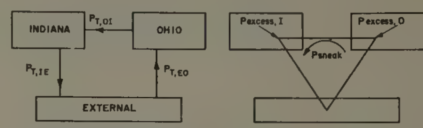

Figure 1. Schematic drawing of the interconnected system

The fact that sneak powers flow in loops of zero-impressed voltage permit their elimination from the total transmission loss formula, which then will contain terms for all generators and $n-1$ excess powers for an n company interconnected system. A typical result of application of the method to the interconnected system of Figure 1 is given in Figure 2.

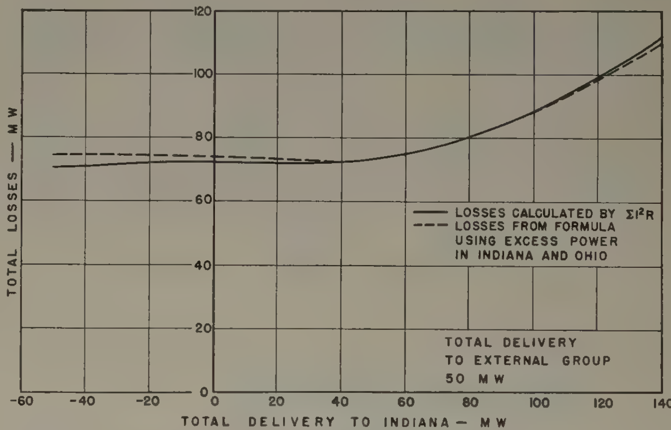

Figure 2. Total losses as a function of total delivery to Indiana

Since the sneak and circulating powers can be expressed in terms of all plant generations and the necessary excess powers, the sneak and circulating powers can be determined numerically for use in calculating individual company loss. Thus the method presented allows determination of total transmission losses in the interconnected system, or individual company loss.

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Aircraft Protection From Thunderstorm Discharges to Antennas

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A current surge conducted along the antenna lead-in frequently damages radio equipment and sometimes causes fires. Therefore a unit was developed which protects the radio equipment and also records the by-passed current and charge magnitudes. The data obtained with these units are presented here.

AIRCRAFT flying under thunderstorm conditions may intercept electric discharges. These discharges may be between different cloud charge areas or in a channel progressing towards and terminating at ground; they differ from familiar concepts of lightning only to the degree that they are most generally in lower current regions of lightning channels. However, a low-flying aircraft may intercept a main discharge channel, and therefore discharge protection also must be adequate for

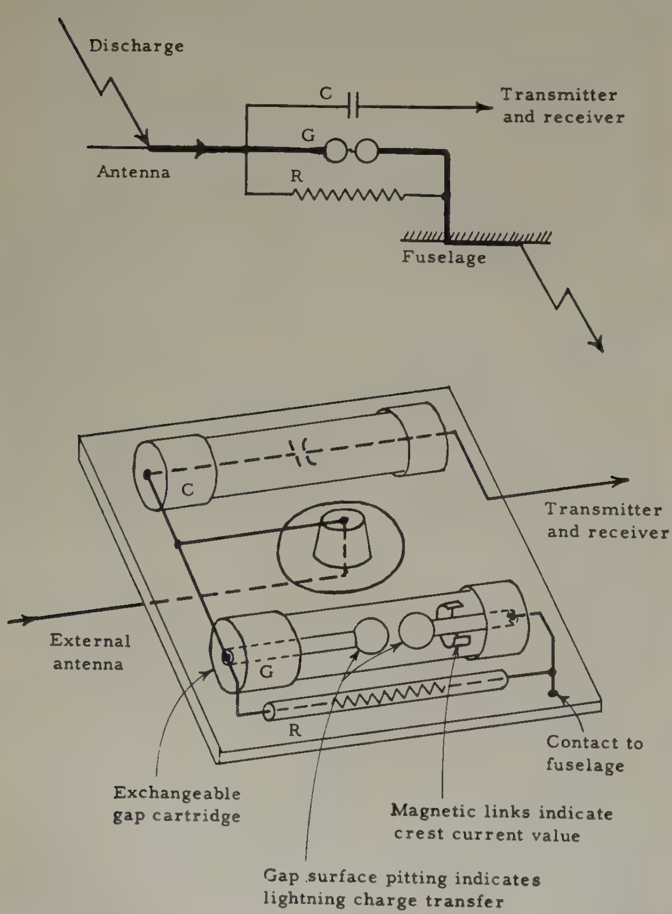


Figure 1. Schematic diagram and drawing of protective and current recording lightning arrester for discharges to antenna

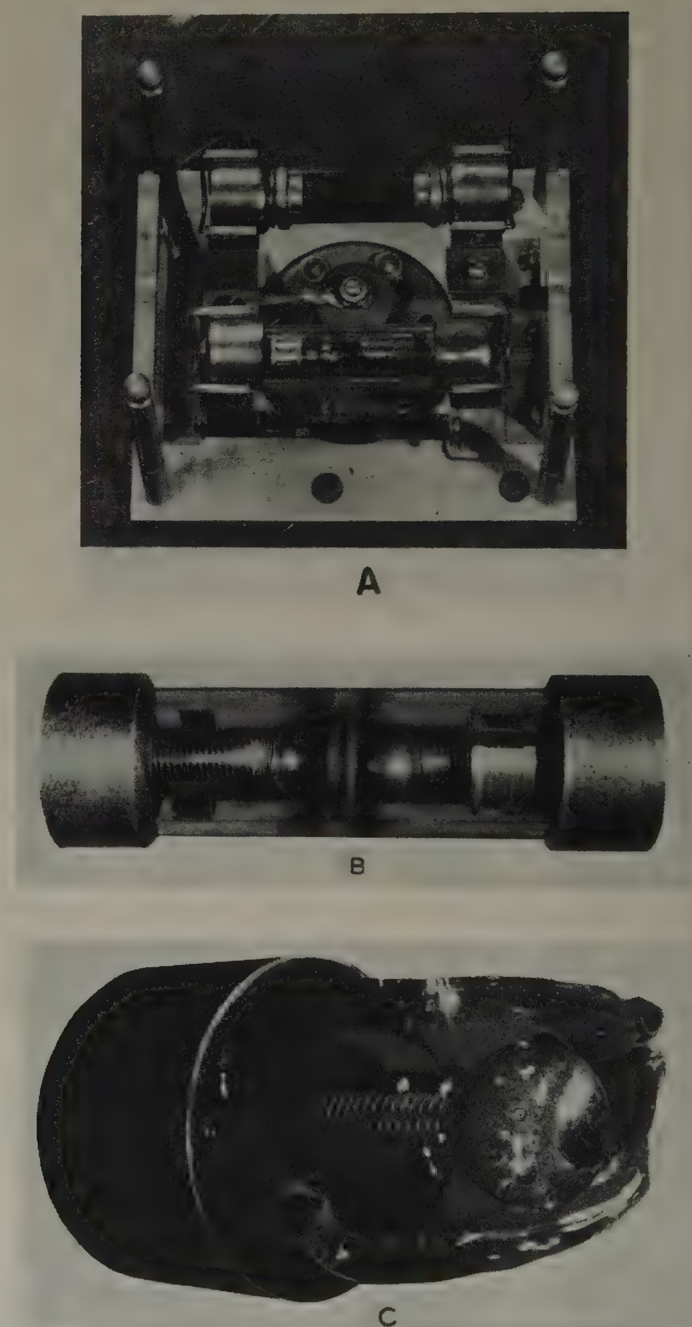


Figure 2. Aircraft antenna protective unit and typical gap cartridges which had safely by-passed discharges to the antenna

A—Protective recorder; B—Gap cartridge which had intercepted a discharge to the antenna of about 25,000 amperes of 10 to 20 microseconds duration. Magnetic strips record crest current values, and the character of spluttering indicates type of discharge; C—Gap cartridge showing how the gas sphere was melted by intercepted long-duration discharge to the aircraft antenna of about 100 coulombs, though crest current did not exceed 5,000 amperes. Most of the gap records were of this type

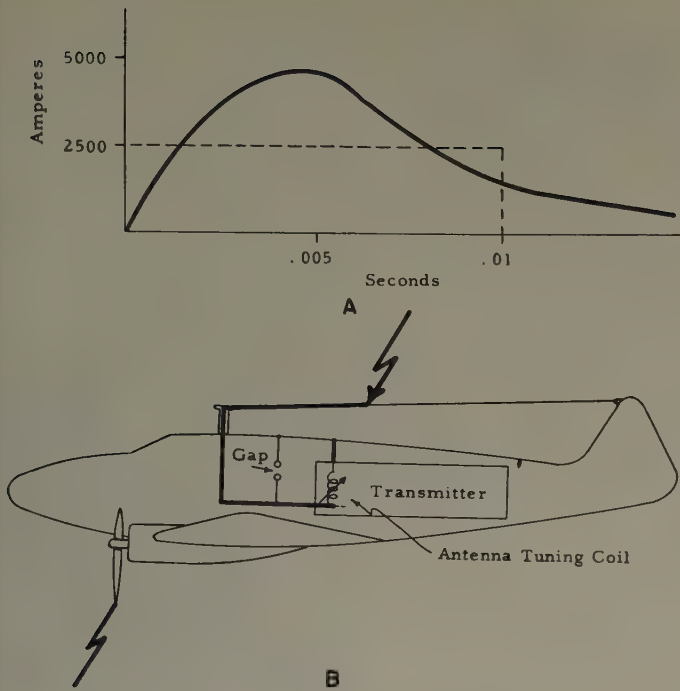


Figure 3

A—Low current rate of rise thunderstorm discharge current indicated by flight returned gaps; B—Lead-in circuit to antenna tuner with usually provided gap intended for protection

the higher current intensities encountered in lightning strokes to ground.

Both theory and experience prove that the metal surface of the aircraft forms inherently a safe discharge current diverting path around occupants and equipment in the interior. However, it has been determined that certain external elements such as movable control surfaces, plastic sections, and outside antennas require protection.

Development of aircraft protective methods has been continuing at the Lightning and Transients Research Laboratory in co-operation with several air lines and under research programs sponsored by the Office of Naval Research and Navy Department, Bureau of Aeronautics, and more recently the Air Forces' Wright Air Development Center. Consequent progress in protective methods was presented and discussed with aircraft manufacturers' and air-line participation in a symposium under the Navy Bureau of Aeronautics' sponsored program at the Lightning and Transients Research Institute.*

The greatest need of improved protection for transport aircraft proved to be in relation to discharges to external antennas entering inside the aircraft, damaging equipment, and occasionally starting fires. A protective scheme, developed under the Office of Naval Research program, as presented in the symposium proceedings, has been used successfully since then on an experimental basis by American Airlines and is presented in this article.

PROTECTION FROM DISCHARGES TO ANTENNAS

From records of air-line experiences it is seen that antennas frequently intercept discharges. A current surge conducted along the antenna lead-in frequently damages radio equipment and in some cases has resulted in fires. Simple by-pass gaps which have been in use at the antenna post are ineffective for many discharge current waveshapes, as indicated by air-line experiences and vividly illustrated by the following excerpt from a pilot's report:

Checked ship for damage, found wires leading in from top antenna burned to a powder. Both transmitter and receiver on high frequency burned out. Flight engineer's hat sitting in radio rack was full of small holes.

* 1948 Symposium *Proceedings*, "Lightning Protection for Aircraft."

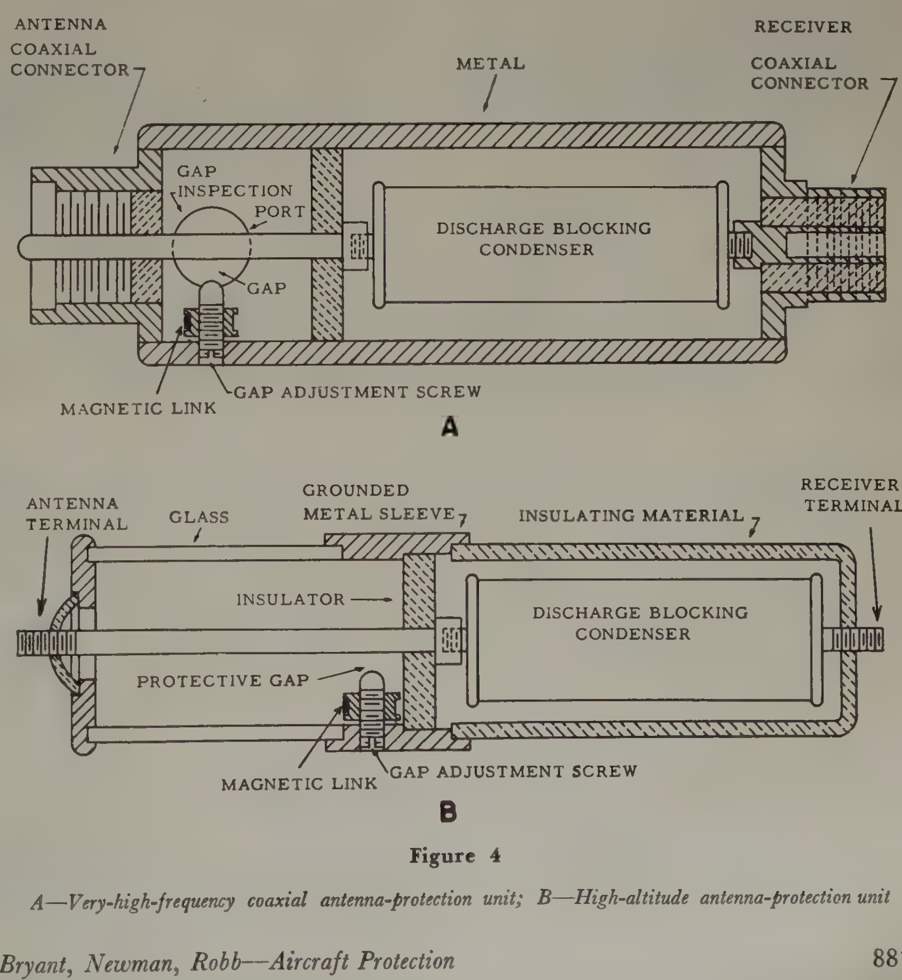


Figure 4

A—Very-high-frequency coaxial antenna-protection unit; B—High-altitude antenna-protection unit

Essentially full text of paper 53-196, "Aircraft Protection From Thunderstorm Discharges to Antennas," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

J. M. Bryant is professor emeritus, University of Minnesota, Minneapolis, Minn., and both **M. M. Newman** and **J. D. Robb** are with the Lightning and Transients Research Institute, Minneapolis, Minn.

Acknowledgment is made of research support by the Navy Department, Office of Naval Research, and the Bureau of Aeronautics, and o. the co-operation of Joslyn Manufacturing Company in lightning protector development.

AIRCRAFT QUESTIONNAIRE ON
Discharges and Atmospherics Effects

Copy to. L & T RESEARCH INSTITUTE
2809 Foshay Tower
Minneapolis 2, Minnesota

A report is requested for each occurrence of discharges to or near the aircraft, or, whenever serious atmospheric radio interference is encountered. This data will be correlated with other aircraft reports and summarized for evaluation of protective measures.

American Airlines (Operating Organization) Aircraft Type DC-6

Geographic location. 20 (Miles) WEST (Direction) from ALLENTOWN, PA. (City and State) Time 4:25 PM Date 7-13-50

Altitude 11,000, Ind. Air Speed 220 mph, Heading 110°, Air Temperature ____ °F ____ °C

Sky was, clear ____, broken X, overcast ____, Freezing level 14,000 ft.

Discharges observed in the vicinity? Yes [ ] No [X]

	Occasional	Frequent
Cloud to ground		
Cloud to cloud	X DISTANT	
Cloud to free space		

Type of precipitation and intensity:
rain X, sleet ____, snow ____, hail ____
light X, medium ____, heavy ____

Strokes to Aircraft

Effects on personnel:
Visual ____
Acoustic ____
Concussion SLIGHT

Effects on Aircraft Instruments:
NONE

Discharge Protective Equipment, if any:
STANDARD DC-6

Damage recorded (continue on separate sheet if necessary, photographs desirable—note parts of aircraft struck on reverse side)
HIGH FREQUENCY ANTENNA BURNED IN TWO. SLIGHT BURN ON RUDDER TAB. HOLE BURNED IN RIGHT ELEVATOR TAB. 8" BURN ON LEFT SIDE OF VERTICAL FIN.

Position of aircraft in relation to local clouds and approximate distances:
IN OPEN SPACE, 5 TO 10 MILES

Turbulence conditions:
None ____, light X, med. ____, heavy ____

Atmospheric Radio Interference

	Light	Med.	Heavy
Atmospherics Static		X	
Precipitation Static	X		
St. Elmo's Fire			

St. Elmo's Fire or corona streamer location ____

Frequency and type of radio equipment on which interference was observed:
HIGH FREQUENCY

Anti-Precipitation Static Equipment, if any
STANDARD

Was trailing antenna used, and if so, how long? ____

Comments:
A BALL OF FIRE ABOUT THE SIZE OF A CANTELOUPE SEEMED TO HIT ON THE RIGHT SIDE OF THE NOSE.

Submitted by L. P. HUDSON (Please Print) (Name) CAPTAIN (Position) Date 8-5-50

Figure 5. Typical questionnaire return involving a discharge to the antenna. The protective recording arrester prevented damage to equipment

An effective antenna-protection unit, shown in Figures 1 and 2, was consequently developed which, besides protecting the radio equipment, also records the by-passed lightning current and charge magnitudes. The principal merit of the method described is that it provides protection against all types of discharge current surges regardless of waveshape, with a minimum of energy transfer into the radio equipment.

The operation of this protective method is as follows: A capacitor C, as shown in Figure 1, having approximately ten times the capacity of the antenna, is placed in series with the antenna lead-in wire and as close to the feed-through insulator as possible. A spark gap G is provided to ground from the antenna side of the capacitor to divert the discharge current to the structure of the airplane. The setting of the spark gap should be such that transmitter voltages will not cause it to arc over. The capacitor should have a breakdown voltage higher than that of the spark gap, with adequate safety margin. When discharges strike the antenna, the capacitor will charge to the spark gap breakdown voltage and the discharge current will be diverted across the gap to the aircraft structure. Thus the maximum surge energy that can go to the radio equipment is the charging energy for the series capacitor, which is relatively negligible. For a typical case of a gap set for 10,000 volts and a 1,000-micromicrofarad protection capacitor the energy transfer would be

$$1/2CE^2 = 1/2 \times 10^{-9}f \times (10^4v)^2 = 0.05 \text{ joule}$$

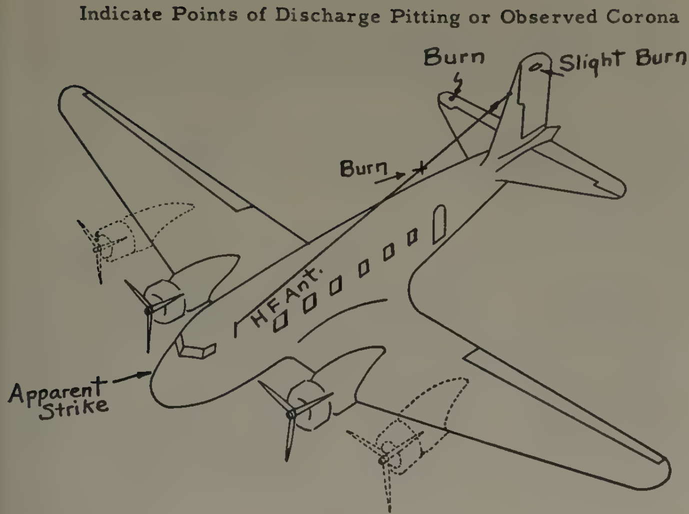
The purpose of the resistor R is to bleed stray charge off the antenna which otherwise might cause corona and associated radio interference.

The need for the series capacitor in addition to the gap used heretofore is illustrated by the following considerations. Many strokes to aircraft involve relatively low current rates of rise as indicated in later paragraphs on flight researches. A typical discharge of this type is shown in Figure 3*A*. Such a discharge would not necessarily flash a simple gap as may be shown by reference to the circuit of Figure 3*B*. This input circuit with simple gap protection at the feed-through point consists essentially of an antenna tuning inductance of approximately 50 microhenrys between the lead-in and the aircraft skin.

With the current wave of Figure 3 the maximum voltage across the coil would be

$$L\frac{di}{dt} = 50 \times 10^{-6}h \times 10^6 \text{ ampere-seconds} = 50 \text{ volts}$$

which is considerably less than that required to flash the protective gap which must be set higher than possible transmitter voltages of 5,000 to 10,000 volts. The charge



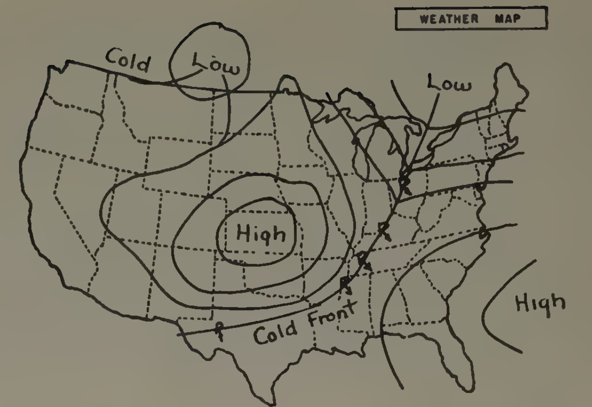


Figure 6. The two parts of the reverse side of typical questionnaire indicating location of discharge points on the aircraft and weather conditions

transfer for this current wave would be the integral of the current waveshape and would be, approximately,

$$0.01 \text{ second} \times 2{,}500 \text{ amperes} = 25 \text{ coulombs}$$

a charge transfer not uncommon for a lightning stroke to ground. This charge transfer in a period of 0.01 second is sufficient to damage an antenna tuning coil but would not, as shown, flash a protective gap.

With a series capacitor in this circuit, the charge transfer would be limited to the charge through the capacitor before the gap breaks down and would be in this case,

$$CE = 1 \times 10^{-9} f \times 5{,}000 \text{ volts} = 5 \times 10^{-6} \text{ coulombs}$$

which is negligible compared to the 25 coulombs, without the capacitor.

Recording features are incorporated simply by mounting steel strips, as seen in Figures 1 and 2, so located as to indicate crest current values by the degree of their magnetization. Analysis of the sphere gap pitting, after a discharge has been passed, indicate the total charge transfer.

New types of protection units are being developed for very-high-frequency stub antennas and for high-altitude

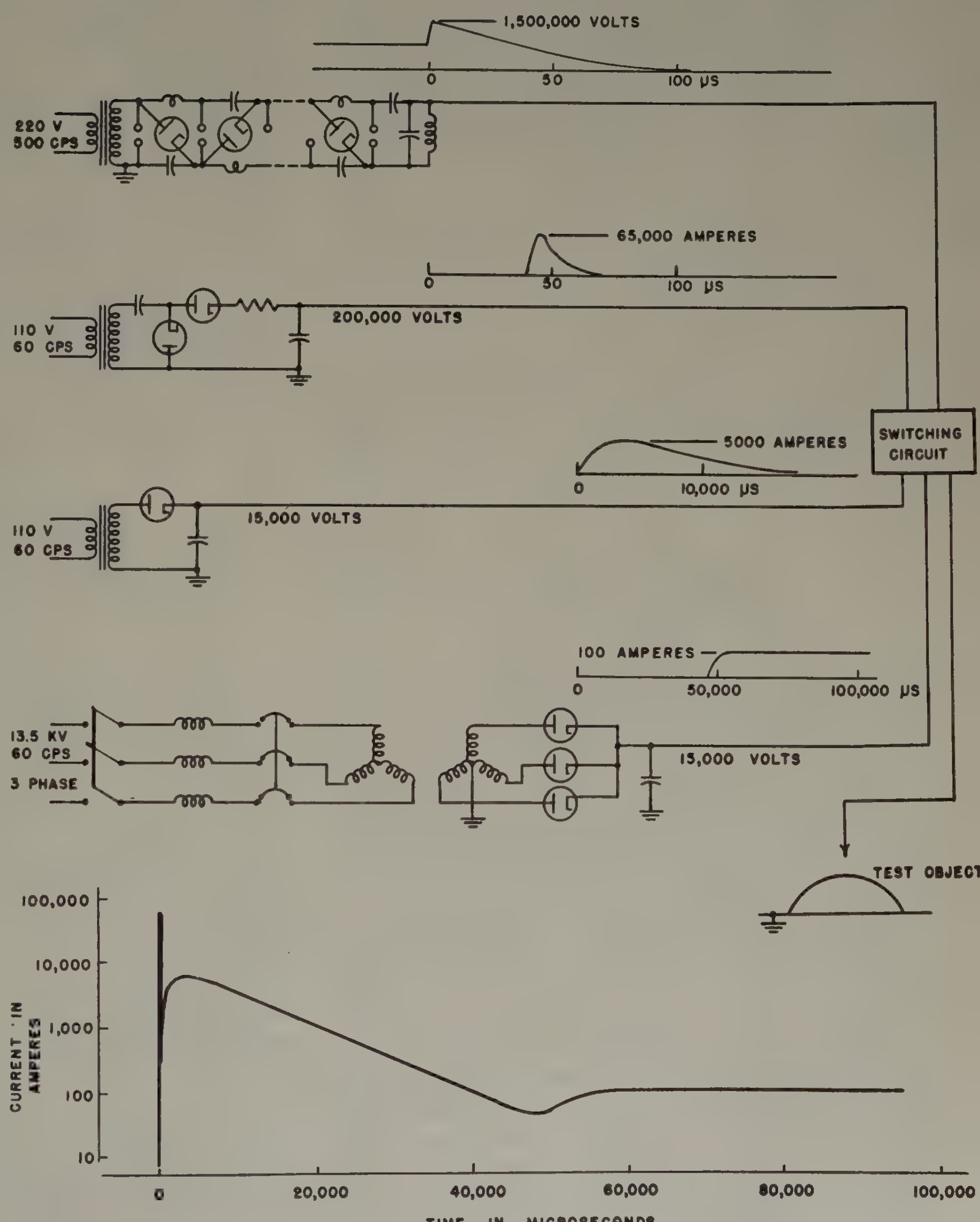


Figure 7. Composite artificial thunderstorm discharge current generator combining initial high-voltage gradient and consequent multiple short- and long-duration current characteristics

operations as shown in Figure 4*A* and 4*B*. The unit for very-high-frequency stub antennas is being designed with coaxial fittings so that the unit merely will be inserted at the point where the transmission line connects to the antenna mast. The entire unit will be replaced in event of a discharge by unscrewing the connectors and replacing with a new unit. The size of this unit can be varied to meet the power requirements of the particular equipment; for low-power very-high-frequency equipment the unit should be no larger than a few cable diameters. The unit shown in Figure 4*B* would replace the present protection units where high-altitude operation required greater leakage distance.

Through the initiative and co-operation of American Airlines, Inc., 50 of the experimental protective and recording units were placed in operation over a 2-year period. Whenever the antenna was struck, the protective gap cartridge was replaced by a spare and the original gap sent to the Lightning and Transients Research Institute for analysis. The lower gap shown enlarged in Figure 2 is typical of about 90 per cent of the returns. In all cases the protective unit provided protection to the equipment and at the same time also contributed new data. Thus it was determined that most of the intercepted discharges were of low current magnitudes (in the order of 5,000 amperes) but of relatively long duration and high charge (in the order of 100 coulombs) transfer. Related data on the discharge encountered were recorded on a simplified questionnaire, illustrated in typical returns reproduced in Figures 5 and 6.

This co-operative arrangement worked out very well as American Airlines was saved radio equipment damage and at the same time the Lightning and Transients Research Institute received quantitative data on cloud-to-cloud-type discharges, which earlier were very limited. Because of the research importance of the data, these experimental protective units are being made available to other air lines interested in co-operating with the Research Institute's program of discharge protection researches.

The data are expected to be of importance in determining the extent to which protection safety margins need to be carried. Also, the data from the returned gaps and questionnaire program eventually should resolve questions as to intensity of discharge currents at various altitudes and locations. Through wider and continued use of the questionnaires it is hoped to resolve also such questions as discharge stroke probabilities to be expected with various operating factors of geographical location, altitude, temperature, speed, and aircraft size.

The maximum burning and melting effects possible with present test facilities which include a high-voltage generator (1,500,000 volts direct current or 3,000,000 volts surge) and a high-current generator (200,000 amperes, 5–10-microsecond waveshape) for producing the standard short-duration AIEE test waves are much less extensive than those observed on flight returned protective gaps. As a result, construction of facilities to produce this flight-observed type of current wave is being undertaken. These facilities will produce a current wave of 5,000 amperes peak lasting 10,000 microseconds, and a current wave of about 100 amperes direct current lasting over 1 second, thus reproducing the large heating effects and charge transfers of actual thunderstorm discharges. As may be seen in Figure 7, these two units will be used in conjunction with the present generators to give one composite wave

Aircraft Flowmeter Measures Jet Fuel Consumption

A mass flowmeter system for accurately measuring the fuel consumption rate of jet aircraft engines has been announced by the General Electric Company.

The equipment determines fuel flow in pounds per hour. It will aid pilots or flight engineers by simplifying the computation of total remaining flying time and permitting a running evaluation of engine operating efficiency through comparison with experience data.

The flowmeter accurately measures the true mass rate of fuel consumption per engine, thereby automatically eliminating fuel density errors due to type and temperature of the fuel.

The apparatus consists of a constant-frequency power supply, a transmitter, and an expanded-scale indicator, located on the pilot's instrument panel, which reads directly in pounds per hour. For multiengine aircraft, a single power supply is capable of operating up to eight transmitters and indicators. Total weight of the system is approximately 11 pounds.

The flowmeter's transmitter, the heart of the system, consists of two identical cylinders placed end to end. Around the periphery of the upstream cylinder, which is rotated by a constant-speed drive, a number of equally spaced holes are placed. Fuel moving down the pipes enters the holes, which change its momentum due to the angular velocity. As this angular momentum is removed from the fuel by the second cylinder, called the turbine, the torque created deflects the turbine against restraining springs. The angular deflection is transmitted to the indicator where the mass rate of flow is registered in pounds per hour on the face of the instrument.

Conductive and radiative radio noise is kept within the limits established by military specifications by means of a filter in the system's power lines. All critical components are internally shock-mounted to withstand any severe vibration.

The transmitter operates up to 12,000 pounds per hour of mass flow and will withstand up to 200 pounds per square inch pressure. It will operate with fuel of any temperature from −55 to 70 degrees centigrade.

Transmitters are mounted in the low-pressure fuel lines which are close to the indicators.

Generator Stator Copper Temperature Indicator

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A MEANS OF measuring the copper temperature of a high-voltage generator conductor is described. A temperature potentiometer measures the temperature drop through the insulation. The temperature drop through the insulation added to the temperature of the outer surface of the insulation is the temperature of the copper.

The resistance temperature detector is commonly used as the temperature guide for operation of the stators of large high-voltage generators. These detectors indicate the temperature at their location in the stator, usually between stator conductors or in the bottom of the slot. In either case they are in contact with the outer surface of the conductor insulation and measure the average surface temperature and not the copper conductor temperature.

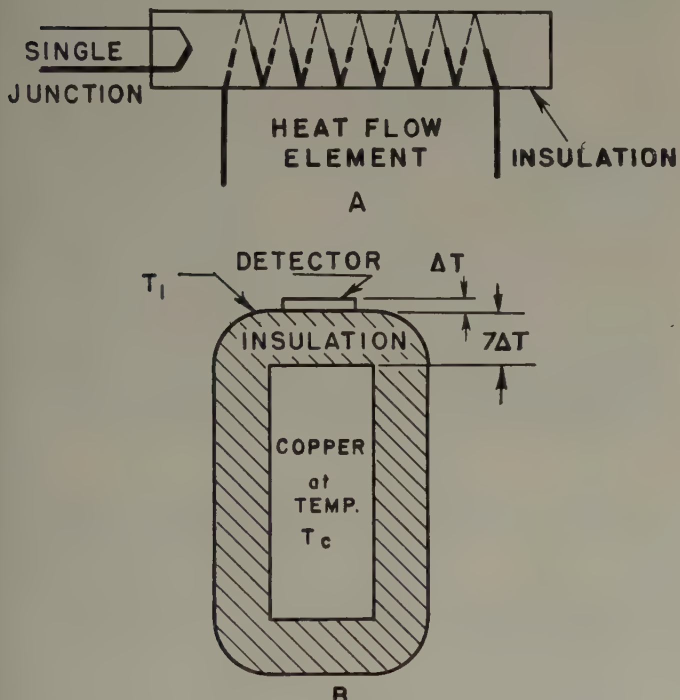


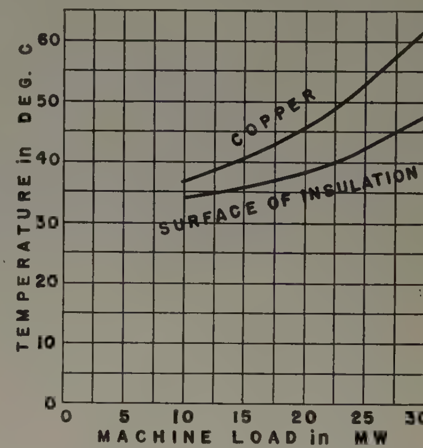
Figure 1. Thermal electric conductor temperature detector and method of mounting

To obtain the copper temperature the temperature drop through the insulation must be added to the temperature of the resistance temperature detector.

The temperature drop through the insulation is variable depending on the generator load, iron temperature, and machine cooling. It can be estimated from data on pilot generators of similar design but preferably should be measured.

Figure 1 shows the means used to measure the temperature drop through the insulation and the stator copper temperature in a 30,000-kw 9,000-volt 25-cycle generator. The heat flow element shown in Figure 1*A* is made up of a thermopile of seven thermocouples and a single junction mounted on a strip of pressed mica 0.030 inch thick, 2 inches long, and 1/2 inch wide. One set of thermal junctions of the thermopile is on one side of the pressed mica strip the corresponding junctions on the other side. This heat flow element (detector) is mounted in a slot wedge with the single junction, and one set of the thermopile junctions in contact with the surface of the conductor insulation as shown in Figure 1*B*.

Figure 2. Copper and surface insulation temperatures of stator winding as a function of machine loading



By test, with a temperature differential ΔT through the detector, the temperature drop through the insulation was $7\Delta T$. The seven thermocouples in the thermopile produce an electromotive force proportional to $7\Delta T$, the temperature drop through the insulation. The single junction and a compensated junction at the measuring instrument produce an electromotive force proportional to T_1 the surface temperature of the insulation. The sum of these electromotive forces is therefore proportional to T_c the copper temperature.

The curves in Figure 2 are plotted from data recorded with the generator in service carrying load. These curves show the variation in temperature of the surface of the insulation and the copper for various loads on the generator.

A modification of the presently used resistance temperature detector method also has been devised utilizing the same principle, that will indicate copper temperature rather than the temperature of the exterior of the insulation as at present.

Digest of paper 53-294, "Generator Stator Copper Temperature Indicator," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

A. L. Brownlee and **H. E. Brown** are with Commonwealth Edison Company, Chicago, Ill.

Electric Drive for High-Speed Surface-Broaching Machine

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The requirements of the electric drive for this high-speed surface-broaching machine are analyzed in detail. This machine is capable of developing a peak of 600 horsepower and can remove rapidly a large amount of metal from a securely held rough forging or casting to an accurate surface finish in one pass of successive broaching tools. It can produce over 150 pieces per hour at cutting speeds exceeding 200 feet per minute.

TODAY'S VERSION of a type of electric drive first described in the AIEE *Transactions* of 1892 has now been combined with a new machine structure and tools to increase production and lower manufacturing costs. Recent development of tools capable of cutting speeds in excess of 200 feet per minute developed a need for a new type of machine structure and a faster and more powerful type of drive. This need has been fulfilled by a high-speed broaching machine, which is capable of producing over 150 pieces per hour at cutting speeds exceeding 200 feet per minute. It requires only one operator on typical large parts and keeps two men busy loading and unloading. Tool life has increased from approximately 4,000 to 50,000 pieces per grind. In one case, 150,000 pieces were broached before regrinding was necessary.

Major work in the development of a high-speed surface-broaching machine was undertaken by the Cincinnati Milling Machine Company in 1934 with the development of a machine capable of a speed of 37 feet per minute and production of 50 to 60 pieces per hour. In spite of some discouragement in the early days, continued progress has been made until today broaching is considered one of the important methods of machining.

The rapid rise of the broaching process has been due to two factors: (1) broaching's ability to remove metal faster than any other comparable method, and (2) it can produce machined surfaces to a high precision and finish. Its application is usually limited to surfaces parallel with the axis of the cutting tool, which have no obstructions in the plane of the broached surface, and where the part is strong enough to withstand the required broaching thrust or can be supported adequately.

A Cincinnati horizontal 2-way broach, machining an automotive cylinder head, is shown in Figure 1. This machine, weighing approximately 90 tons, is capable of developing a peak of 600 horsepower. It occupies a floor space of approximately 19 by 51 feet, a tremendous saving in space over previous methods of obtaining this production. When shipped, it was a full capacity load for a 45-foot flat car. The function of this machine is to remove rapidly a large amount of metal from a securely held rough forging or casting to an accurate surface finish in one pass of successive broaching tools.

The first procedure in the design was the outline of requirements and review of past performance. Some of the factors considered were

1. Power requirements based on maximum amount of stock removed and maximum cutting speed.
2. Fixture and tool requirements.
3. Material handling.

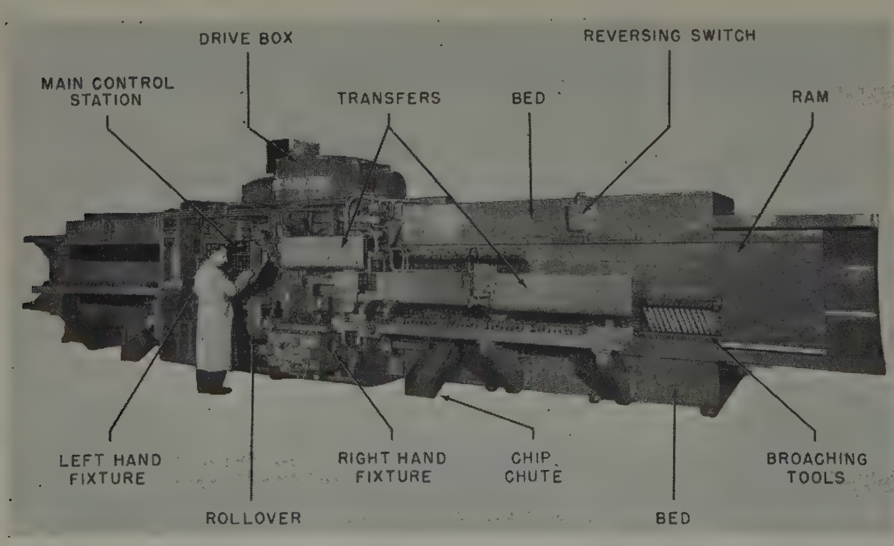

Figure 1. Cincinnati high-speed surface-broaching machine

The basic design was blocked out to determine:

1. Principles of operation and the relation of various units.
2. Type of drive to meet the requirements.
3. Principles of work holding and method of work movement.

The next step was to complete

Revised text of a paper presented at the AIEE Special Conference on Machine Tools, Albany, N. Y., October 29, 1952, and recommended for publication by the AIEE Subcommittee on Machine Tools.

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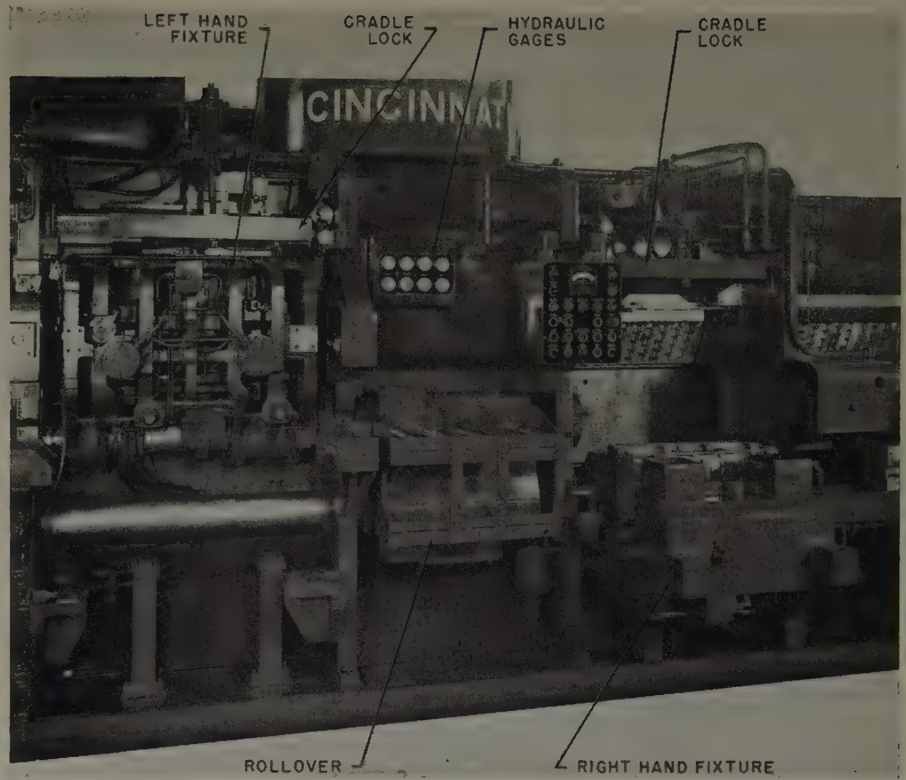
Figure 2 (right). Work holding fixture



the layout of each unit in terms of sound engineering principles, keeping in mind the large forces developed. Since this is a key machine in line production, its down time represents large losses so the design was carefully reviewed for safety and ease of maintenance and service.

The machine, Figure 1, consists of the following units:

The All-Steel Bed. The bed supports all of the elements and must handle all of the reactive forces. It is of all-welded construction approximately 6 feet wide, 7 feet high, and 37 feet long.

The complete structure is reinforced to form uniform compartments using steel plates and box sections. The total weight of the bed units is approximately 50,000 pounds, and is thoroughly stress relieved.

Reciprocating Ram. The reciprocating ram carries the cutting tools past the work. The complete unit weighs 12,000 pounds, and is stress relieved. The driving rack is fastened to the back of the ram and travels at approximately 200 feet per minute for a stroke of 18 feet. This unit has more than 5,000 square inches of bearing surface to support the high cutting loads.

Driving Mechanism for the Ram. The ram is driven by an adjustable-speed d-c motor directly coupled to a rack and pinion through a 20 to 1 reduction worm and wheel, having a vertical axis output pinion engaging the ram rack. This is the only mechanical tie between the prime mover and the ram.

The Work-Holding Fixture. The right-hand work-holding fixture is shown in loading position and the left-hand fixture is shown in cutting position in Figure 2.

Because of the large amount of metal removed per minute, the fixture must be massive to hold the part firmly and to obtain the necessary rigidity and freedom from vibration.

The major forces exerted by the cutting tool are in two directions, one parallel to the direction of the ram movement, and the other at 90 degrees from this.

When the fixture is indexed into position, the locking bar is lowered over the clamping pads to tie the fixture into the upper machine structure, thereby resisting the separating forces.

Work Piece Transfer Mechanism and Rollover. The transfer mechanism, built in two sections, is hydraulically operated. The movement of the transfer mechanism is parallel to the ram. In its right to left stroke it transfers the part from the right-hand fixture to the rollover and moves the new part into the right-hand fixture.

The rollover receives the part completed by the right-hand fixture, turns it 180 degrees during the fixture index and stores the part until the next cycle. Since the machine cuts in both directions the tools are in two different levels; consequently, the work in being turned must be deposited at a higher level.

In the next stroke the part in the left-hand fixture is transferred to the outgoing conveyor and the part from the rollover is transferred to the left-hand fixture.

The Broaching Tools. Tungsten carbide inserts are used in most tools for these machines. These tools, or bits, must be strong enough to withstand the cutting force and spaced to allow the chips to be carried away freely.

The stock removal per tool on the roughing operation is usually 0.015 inch to get under the scale, reducing from 0.005 to 0.008 inch in the completion of the roughing operation. The finishing tools are full width tungsten carbide blades as shown in the right hand of Figure 1 and set to remove 0.002 inch per blade at the start and 0.001 inch at completion.

Operating Power Plant. The original hydraulically driven machine using five motors was later changed to use eight 30-horsepower motors driving the hydraulic pumps, resulting in a machine capable of a 60-foot-per-minute speed.

This proved that it would be impractical to use such a drive for a machine which would have the power and speed capable of taking full advantage of the cutting speed of tungsten carbide tools which is much more rapid.

Several types of drives were considered. The hydraulic drive and its limitations were outlined above. The a-c motor clutch-brake combination was analyzed. It greatly increased the mechanical difficulties in applying the various units. In addition, clutches to meet the required torque rating greatly increased the cost of the drive.

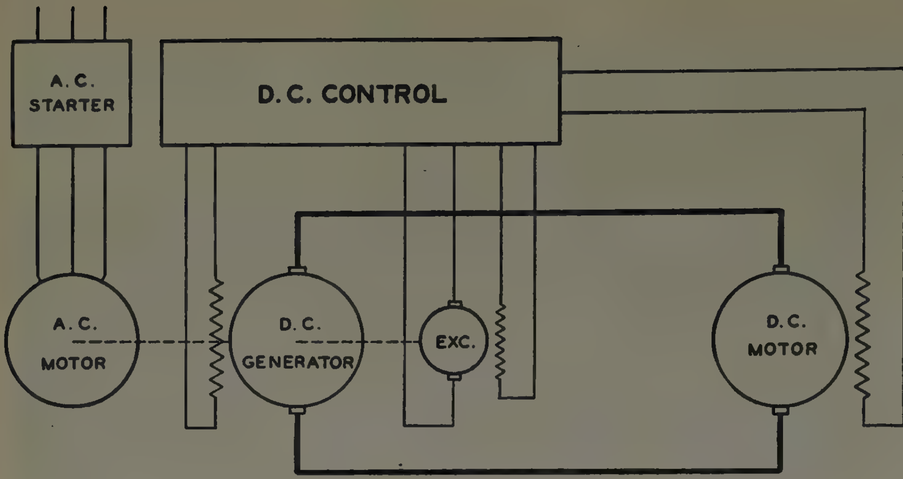


Figure 3. Loop circuit

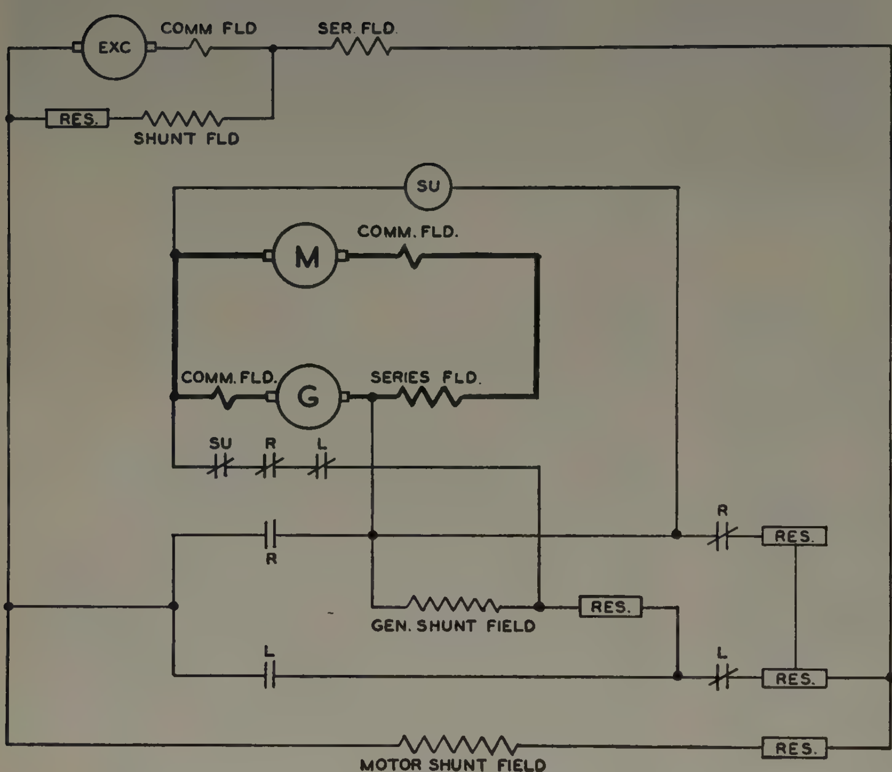


Figure 4. Stopping and reversing control

An a-c reversing motor drive with plug-stopping and an adjustable-voltage drive were analyzed also. A comparison of these drives is given in detail below. After comparing the advantages and disadvantages (including cost) of all the drives, an adjustable-voltage drive was selected as best fulfilling the requirements.

The following comparison between an adjustable-voltage drive and an a-c reversing-motor drive with plug-stopping gives some idea of the advantages and features to be gained by using an adjustable-voltage drive.

The drive requirements were analyzed as follows:

Maximum Power Requirement and High-Speed Operation. Both of these requirements would be met adequately by either the adjustable-voltage drive or the a-c reversing-motor drive with plug-stopping.

Starting. This machine has a momentary peak requirement of 600 horsepower but has an rms horsepower requirement of less than half of that. This momentary peak requirement dictates that a 300-horsepower motor with at least 200-per-cent pull-out torque should be used. In turn, this would require a size 6 starter on 440 volts.

On the a-c drive, mechanical life on such a large starter would present quite a problem when operated four or five times per minute. The problem would be further complicated with reduced voltage starting.

The adjustable-voltage drive does not have this problem. As shown in Figure 3, the main-drive a-c motor is started and runs continuously. The loop circuit is solidly connected, and consequently the life of large a-c starters is not a factor for consideration.

Stopping and Reversing. In automatic operation, the ram must stop quickly, wait for other functions, then run in the opposite direction. This requires a reversing starter for plugging and reversing, and doubles the number of operations on the starter. This would probably require the use of ignitron contactors.

Again, the adjustable-voltage drive does not have this problem. As shown in Figure 4, when a signal is given telling the ram to stop, the generator field discharges (at a rate which can be controlled), and the motor regeneratively brakes to a stop. The suicide field connections (as shown in Figure 4) prevent the motor's creeping at low speed, and help to give a positive, accurate stop. Reversing is obtained by reversing the generator field (which can be done with small, long-lived relays) without the necessity for opening the loop circuit.

Motor Heating. A standard 300-horsepower motor without load cannot be started more than once every few minutes without overheating. It could not be plug-stopped four or five times per minute continuously without burning out. Special a-c motors could be constructed which would fulfill the requirements, but they would have to be of special design to dissipate the heat.

The adjustable-voltage drive does not present a heating problem. When the motor is stopped, the generator field voltage is reduced to zero. As soon as the motor counter-electromotive force exceeds the generator voltage,

the motor turns into a generator and pumps its energy back into the generator, and in turn back into the line. The heating of the motor is greatly reduced.

Accuracy of stopping. The plugging torque of an a-c motor changes when the motor heats up. The change is even more pronounced when the motor has a high-resistance rotor. This would result in undesirable variations in stopping.

Since the time constants in the generator and motor fields and in turn the braking torque depend primarily upon the inductance, the adjustable-voltage drive provides a very accurate stop, which will vary very slightly as the motor and generator heat up.

Constant cutting speed. The ram speed must remain essentially constant while cutting in order to obtain the proper finish. An a-c motor with a high-resistance rotor would have a drooping speed characteristic, and the ram speed would vary with the load.

In the adjustable-voltage drive a series field in the generator, or other means of compensation, increases the generator voltage as the cutting load increases and compensates for the increased voltage drop in the armature. The speed remains practically constant.

Adjustable speed. High-speed broaching machines are basically high production machines, in that they are used to produce repetitively large quantities of parts, with accuracy and finish being important requirements. Consequently, there is no need for the operator to change speed. However, the cut in one direction may be much heavier than in the other direction, and, in some applications, the machine cuts only in one direction. Material changes also may require a different speed. Because of the above reasons, adjustable speed would be desirable.

With the a-c motor drive, the speed would be a function of the motor speed and the gearing. In order to transmit the high torque requirements, these gears would be large and difficult to change. Independent directional speed without clutches would be impractical.

On the adjustable-voltage drive tapped resistors are supplied in series with the generator and motor fields. Figure 5 shows how the speeds can be adjusted, with each direction completely independent from the other. With minor changes in the control circuit the cutting speed could be changed during the stroke, should this be required.

Slow jog speed. On a broaching machine of this type a slow speed is used for checking clearances when tool holders are changed, and in cases where it is desired to observe the action of the broaching tools. Where an excessively hard block, extremely dull tools, or power failure causes the ram to stall in a cut, a slow speed is desirable to complete the cut.

A 2-speed motor could be used as part of the a-c drive, along with a 2-speed starter and associated control. With this a speed of 1/2, 1/3, or 1/4 of the cutting speed could be obtained.

In the adjustable-voltage drive a jogging circuit, as shown in Figure 5, is used, and the jog speed can be set at whatever value is desired. In general, this speed is set at a value to limit the loop circuit current and correspond-

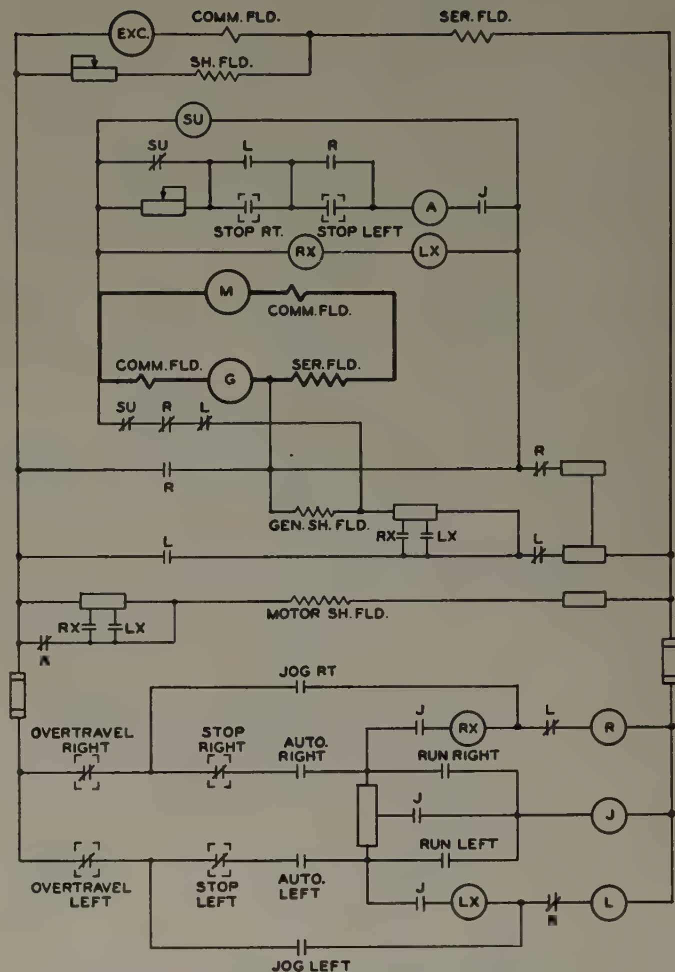


Figure 5. Typical adjustable-voltage drive control

ing torque to safe values, rather than setting a particular speed.

Overload capacity. The complete cycle of a 2-way broach includes time at each end of the stroke while the blocks are being unclamped, transferred, and reclamped. The broaching load is not constant, but depends on the amount of stock being removed by a particular set of tools and the condition of the tools. It normally has two or three peaks until the finishing tools are reached, and then tapers off, as shown in Figure 6. The drive must be able to deliver the peak requirements, with a safety factor to take care of excessive stock, hard material, and dull tools.

The pull-out torque of the a-c motor will determine the momentary peak load that could be delivered by the a-c drive. Since the efficiency of the a-c drive would be higher than the adjustable-voltage drive (due to the use of the generator and motor on the adjustable-voltage drive), the same size motor could stand a higher momentary peak load when used on the a-c drive.

Using a typical adjustable-voltage drive to make comparison, a 100-horsepower drive is rated 100 horsepower at 250 rpm with approximately 115 volts applied to the armature of the motor. Strengthening the generator field to its full strength increases the armature voltage to 350 volts, the speed to 750 rpm, and the horsepower to 300 horsepower, but with no increase in current. Speeds higher than 750 rpm are obtained by weakening the motor

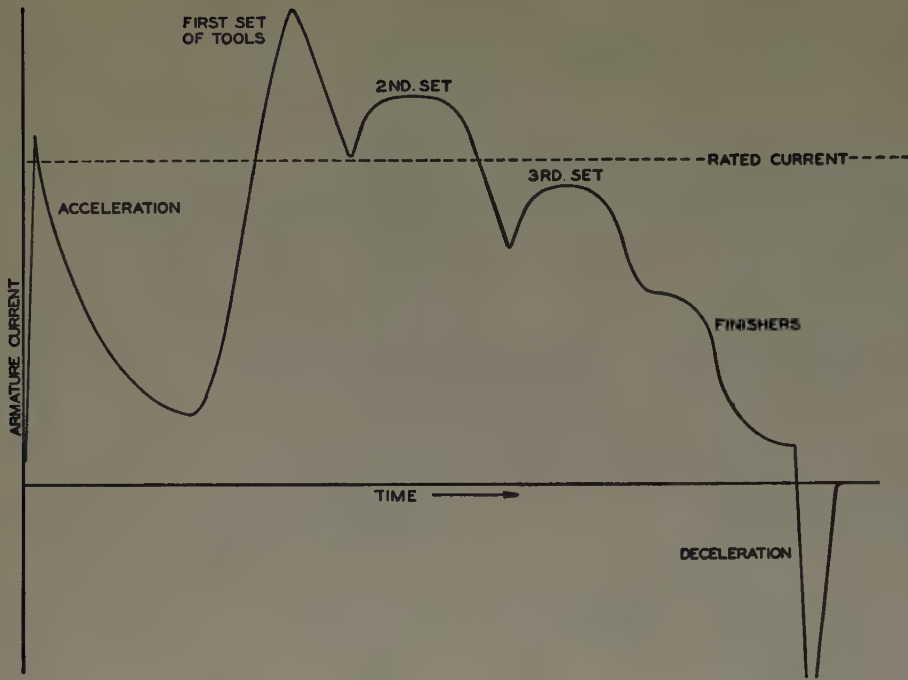


Figure 6. Typical load curve

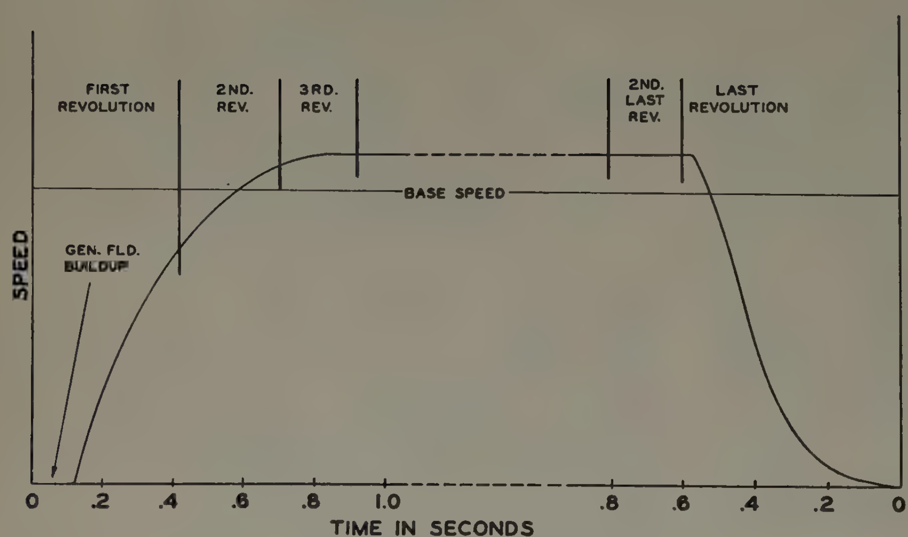


Figure 7. Acceleration and deceleration of ram motor

field, with consequent increase in armature current. Since this gives a less favorable torque per ampere ratio, cutting speeds are normally limited to approximately 900 rpm. The actual overload that can be delivered is a function of the commutating ability of the motor and generator, and the pull-out torque of the a-c driving motor. A 300-horsepower a-c driving motor with a pull-out torque of approximately 230 per cent (standard for the *TEFCBB* motor used) delivers enough torque so that approximately 600 horsepower can be delivered by the d-c driving motor.

The inertia of the d-c driving motor as well as the inertia in the motor-generator set contribute to the overload capacity, since they contribute a flywheel effect that helps carry the unit through the heavy momentary overloads. This compensates for the higher efficiency of the a-c drive.

Accelerating and decelerating. In the high-speed broach, the ram comes to rest at the end of each stroke. At the same time finish requires that the ram speed remain essentially constant while cutting. This means that any time taken for accelerating and decelerating results in a longer cycle time, and also a longer machine. At the same time, too rapid acceleration and deceleration results in shock, which shortens the machine life.

The a-c drive accelerating torque would depend upon the starting torque of the motor, while the decelerating torque would be dependent upon the plugging torque. In order to avoid excessive shock when plugging torque is applied, plugging resistors probably would be required.

The speed of response of the adjustable-voltage drive is very fast, but due to the time constant in the generator and motor fields, is limited to values which normally avoid shock. At the same time, the speed of response, particularly decelerating speed, can be changed if this should be required. Figure 5 shows the generator field discharge resistors, which can be used to change the speed of deceleration. If exceptionally fast deceleration is desired for stopping the motor the generator field can be plugged. The speed of response of a typical adjustable-voltage drive is shown in Figure 7.

Conformity with Joint Industry Conference (JIC) electrical standards. JIC standards specify that all a-c motors be totally enclosed. As stated above, this would be very hard to do with an a-c motor that had to be plug-stopped and kept cool at the same time. For that matter, JIC standards discourage the use of special motors.

The adjustable-voltage drive does not conform completely with all JIC electrical standards. The main-drive a-c motor is a standard totally enclosed, fan-cooled, ball-bearing motor. The d-c generator and drive motor are provided with filters to exclude dust and foreign materials, and have received our users' approval. The control conforms with JIC electrical standards.

Cost. In its simplest form the a-c drive would be lower in price than the adjustable-voltage drive.

The adjustable-voltage drive was selected on the basis that it offered a better solution to the problem due to its added flexibility and features.

As described herein, the d-c drive and the associated motor-generator set do a very adequate job of providing the power for driving the ram through very heavy cuts. At the same time, this power must be properly controlled, in order to obtain proper operation of the machine. The typical adjustable-voltage drive shown in Figure 5 is controlled by seven relays and four heavy-duty limit switches, (in addition to the main motor starter). The limit switches are designed for this type of service. The seven relays are small, long-lived, and give long, trouble-free service.

AUXILIARY EQUIPMENT

In addition to the adjustable-voltage drive and its control, there are many auxiliary functions that must be provided and properly controlled. The auxiliary control is made up of 7 motors, 6 starters, 53 relays, 34 push buttons and indicating lights, 15 solenoids, 4 pressure switches, and 15 limit switches.

Hydraulic power and lubrication is supplied from a central source. The motors, pumps, and related equipment to supply lubricating oil to rams, ways, worm, and wheel are mounted on the tank.

This unit also supplies hydraulic oil for raising and lowering the fixture, for clamping the work, and for the transfer and rollover operation.

Auxiliary functions such as clamping, transferring, and indexing are hydraulically powered and controlled through solenoid valves and relays. The control is all made sequential, in that one function must take place and close a limit switch before the next function can be performed.

DESIGNED SAFE OPERATION

Safety was given the highest priority in this design. It hardly is necessary to review the more conventional sequence interlocking arrangements, which prevent wrecks and mishandling by the operator, but a few of the different safety features in the machine are interesting.

The fixture locating pads are designed to permit the passage of a fixed amount of air. When the orifices are blocked by the part being properly located the pressure increases, operating a pressure switch which permits the next function. This system has eliminated all of the troubles due to dirt, sticking plungers, and so forth, and locates the casting within 0.002 inch.

An ammeter at the operator's station constantly indicates the cutting load. When this load increases beyond normal, it is an indication to the operator that the stock is heavy, the material is hard, or the tools are dull.

Should the load exceed the capacity of the drive or the power fail, the ram may stop in the middle of a cut. The operator can jog the ram at a low speed to complete the cut.

Stopping of the ram is through heavy-duty limit switches operated by dogs carried on the ram. Should the electric circuit fail or the dogs move, the rack is designed to run off of the pinion. To dissipate the inertia of the ram a soft steel plate is bolted to it and located to travel past cutting tools fixed in the bed. These cutting tools, removing approximately 1/8 inch of metal, readily dissipate the energy, and bring the ram to a stop.

MACHINE OPERATION

Complete individual unit operation is provided through push button control. An automatic cycle is as follows:

1. With right-hand fixture down and work loaded but unclamped, operator shifts lever clamping work.
2. Operator presses "Preset and Cycle Start" buttons.
3. Left-hand cradle lock raises.
4. Right-hand fixture swings into cutting position and left-hand fixture moves into unloading position.
5. During down movement, work unclamps in left-hand fixture.
6. Right-hand cradle lock swings into locking position.
7. Ram starts cutting to the left.
8. While ram is cutting, the left-hand transfer moves to left and moves work out of the fixture on to outgoing conveyor and the part from the rollover is transferred into the fixture. The transfer returns to starting position.
9. When ram reaches left end of stroke, it stops, completing one-half cycle.
10. Operator shifts lever on left-hand fixture, clamping work.
11. Operator presses "Preset and Cycle Start" buttons.
12. Right-hand cradle lock raises.
13. Left-hand fixture swings into cutting position and right-hand fixture moves into unloading position.
14. During down movement work unclamps in right-hand fixture.
15. Left-hand cradle lock swings into locking position.
16. Ram starts cutting to the right.
17. While ram is cutting, the right-hand transfer moves to left and moves work from right-hand fixture to rollover and a new part is moved from the conveyor into the right-hand fixture. The transfer returns to starting position.
18. At end of stroke, ram stops, completing full cycle.
19. Repeat step 1.

Should operator complete the loading and clamping of a part and operate the "Preset and Cycle Start" buttons, the circuit holds until the ram stroke is complete and then automatically starts the next cycle.

This cycle is completed in the following time:

	Minute
Index right-hand fixture	0.080
Broach 18 feet apiece at average of 180 feet per minute	0.100
Index left-hand fixture	0.080
Broach 18 feet apiece at average of 180 feet per minute	0.100
Total time per cycle	0.360

CONCLUSION

The mechanical, electrical, and hydraulic divisions of the engineering department worked very closely with the manufacturing division during the original design of this machine. The resulting design was so sound that operating reports received on the original machine did not suggest any significant changes before manufacturing a large quantity of these machines.

Tests show that the cutting time can be further reduced. However, this will not appreciably affect the over-all cycle. How to reduce the material handling time is the problem confronting engineers at present.

Lightning Investigations at 115/230-Kv Stations

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IN 1947 THE Hydro-Electric Power Commission of Ontario instigated a survey at its Burlington and Leaside 115/230-kv transformer stations to determine the effectiveness of the lightning protection provided by overhead ground wires, used to protect the stations from direct lightning strokes, and by co-ordinating gaps, used in place of the more conventional lightning arresters to protect the power transformers from severe overvoltages.

A limited number of installations of the conventional capacitive-coupled klydonographs were made at these stations some years ago; however, the development by the Commission of a simple direct-coupled klydonograph[1] (Figure 1) eliminated the requirement for capacitive-coupling devices and allowed changing the units without service interruptions by means of live-line tools, thus making possible a much more extensive survey.

Lightning arresters at the 230-kv Leaside transformers have been monitored for 20 years. Rod gaps set at 40 inches at the 230-kv Burlington transformers never have operated, so they were reduced to 36 inches for the 1952 lightning season to provide a greater protective margin for the transformers. The lightning protection at the 115-kv transformer terminals at Burlington consists of 18-inch rod gaps and there is no lightning protection at the 115-kv transformer terminals at Leaside. No records of lightning discharges through the arresters or gaps have been recorded at any of these installations.

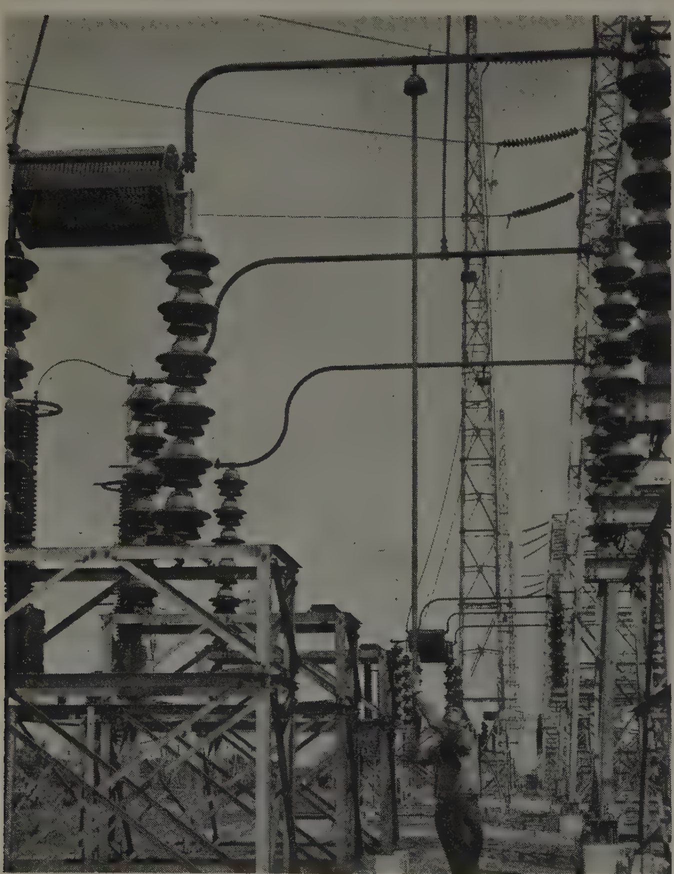

Figure 1. Installation of klydonographs at Burlington transformer station

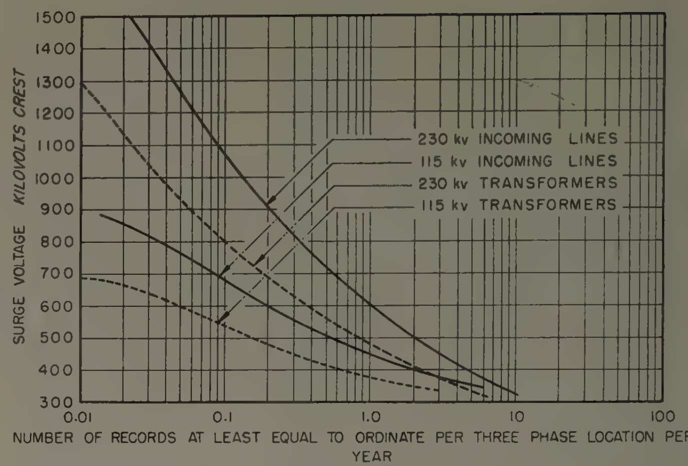

Figure 2. Frequency of occurrence of voltage surges at 115/230-kv transformers and at the incoming lines

The frequency of occurrence of voltage surges at the transformer terminals and at the station entrance is shown in Figure 2. The severity of voltage surges recorded at the transformer terminals is approximately 0.75 of that at the station entrance.

The average frequency of occurrence of voltage surges at the 230-kv transformer terminals, greater than 800 kv, is one every 10 years per transformer bank and at the 115-kv transformer terminals, greater than 400 kv, is one every 2 years per transformer bank. For a small percentage of these surges a co-ordinating gap might fail to protect the transformer insulation.

A direct lightning stroke was recorded to the second 230-kv tower span from Burlington station producing 1,300 kv on the top-phase conductors of the double circuit line. At the station entrance these surges were reduced to 300 kv. From the attenuation observed in this survey, there is little possibility of damage to station equipment from short-duration surges produced by direct lightning strokes to a transmission line close to a station.

REFERENCE

1. A Simplified Double-Film Klydonograph With an Improved Coupling Method, **J. H. Waghorne.** AIEE *Transactions*, volume 66, 1947, pages 1114–16.

Digest of paper **53-118,** "Lightning Investigations at Two Major 115/230-Kv Stations," recommended by the AIEE Committee on Protective Devices and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Power Equalizer Systems for Aircraft Alternators

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THE 400-CYCLE 120/208-volt a-c electric system presently in use on operating aircraft uses both reactive and real power equalizers to assure equal division of load among the paralleled alternators. Use of analytical methods to predict conditions is desirable.

The reactive power equalizer can be schematically represented by Figure 1, where I_1, I_2, ..., and I_n represent the line currents flowing from each alternator of the system; i_1, i_2, ..., i_n are the currents in the mutual reactor of each alternator's voltage regulator; and c is the current transformer ratio. The expression for i_1 in terms of the line current unbalance is

$$i_1=\frac{n-1}{c}(I_1-I_n) \tag{1}$$

The circuitry of the voltage regulator is such that only the current in the mutual reactor which is in quadrature with the reference voltage effects any change in alternator excitation; so, using equation 1, expressions for the bus voltage in terms of the voltage regulator settings, $|V_{01}|$ and $|V_{0n}|$, of the first and nth machines can be developed:

$$|V|=|V_{01}|-K\frac{(n-1)}{n}(|I_1|\sin\theta_1-|I_n|\sin\theta_n) \tag{2}$$

and

$$|V|=|V_{0n}|+\frac{K}{n}(|I_1|\sin\theta_1-|I_n|\sin\theta_n) \tag{3}$$

where K is a positive constant of the regulator, θ_1 and θ_n are the phase angles of the line current of the first and nth machines, and the vertical bars denote magnitude of phasor quantities.

These equations can be used to determine the bus voltage for the following system disturbances:

1. Failure of the voltage regulator where one alternator of the system is held at ceiling excitation.
2. Open alternator field circuit on one alternator.

Application of the voltage expressions also can be made to the case where there is error in the setting (V_{01}) of one alternator and the reduction of installed capacity caused by this error can be computed.

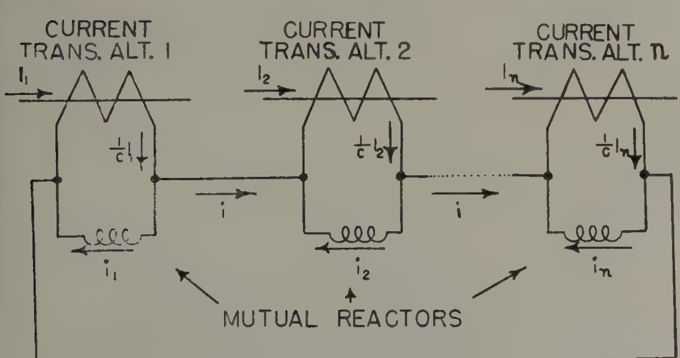

Figure 1. Schematic diagram of reactive power equalizer

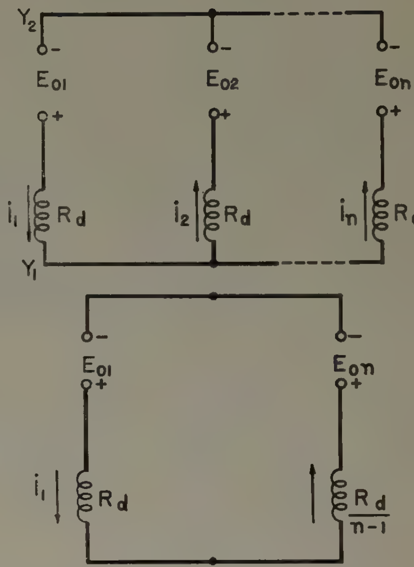

Figure 2. (Top) Schematic diagram of real power equalizer. (Bottom) Simplified equivalent circuit

The real power equalizer employs an interconnection of the droop circuits of the system alternators. In this way trimmer adjustments to the output speed of the variable-ratio alternator drive are made to assure equal division of real load.

Figure 2 is a schematic representation on the real power equalizer network. E_{01}, E_{02}, ..., and E_{0n} are d-c outputs of the droop circuits of the n alternators, each of which is proportional to the inphase component of current flowing from its alternator. R_d represents the resistance of the droop coil of each variable-ratio drive.

Expressions analogous to equations 2 and 3 then can be developed for frequency. These are

$$f=f_{01}-K'\frac{(n-1)}{n}(|I_1|\cos\theta_1-|I_n|\cos\theta_n) \tag{4}$$

$$f=f_{0n}+\frac{K'}{n}(|I_1|\cos\theta_1-|I_n|\cos\theta_n) \tag{5}$$

where f is the bus frequency, f_{01} and f_{0n} are the reference settings of the variable-ratio drive governor, and K' is a constant associated with the governor.

The frequency expressions can be applied to determine the loss of installed capacity due to errors in governor setting, but other applications are somewhat limited unless the equations are modified to be expressions for the output speed of each drive.

Digest of paper 53-179, "Power Equalizer Systems for Aircraft Alternators," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Southern District Meeting, Louisville, Ky., April 22–24, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Sealed Dry-Type Transformers Proved Safe by Test

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Tests were made to determine to what extent gross mistreatment of sealed dry-type transformers with Class H insulation might involve fire or explosion hazards. Tests on sealed transformers containing no organic material other than a small quantity of semiorganic silicone varnish indicated they may be operated with almost no danger of fire or explosion.

ONE OF THE results of the multiplying uses to which electricity has been put is the demand for large quantities of electric power in restricted areas. Public buildings, office buildings, and particularly factories require large concentrations of power in relatively small areas. Large blocks of power at utilization voltages, in turn, have emphasized the economy resulting when transformation to the utilization voltage is done close to the load. For such service, a safe transformer free from hazard of fire or explosion is needed.

Until a few years ago, almost all transformers for ratings of more than a fraction of 1 kva were immersed in mineral oil. They were located in outdoor locations, usually in a substation surrounded by a steel fence. The mineral oil used in such transformers has a fire point of approximately 152 degrees centigrade and above this temperature will burn freely in air. Also, an electric arc in the oil produces combustible gases which, in the presence of air, can form an explosive mixture. A considerable portion of the development in design and operation of oil-immersed transformers has been directed toward minimizing the fire and explosion hazard. Anyone connected with the design or application of transformers could make a long list of such developments. Among the important ones are differential relay protection, inert gas blankets over the oil with adequate gas space to cushion the pressure shock, pressure relief devices, network protectors, reverse-power relays, sudden-pressure relays, overload relays, properly applied lightning arresters, and general improvement in insulation levels. For transformers in outdoor protected areas where the hazard is almost entirely one of property damage or service interruption, these devices have reduced the possibility of fire and explosion to the status of a relatively minor problem. However, when the transformers are moved indoors into buildings and factories, where people live and work, fires and primary and secondary explosions are a hazard to life and more rigid safety requirements are a necessity.

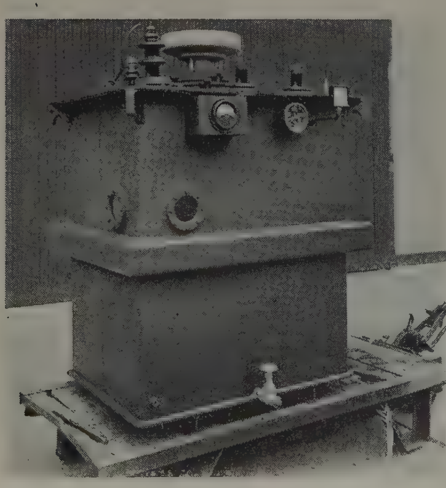

Figure 1. Test transformer

One solution of the safety problem is to put the oil-immersed transformer in a vault and surround it with fire walls. It is an expensive solution and requires relatively long secondary lines at utilization voltages. Another solution is to substitute a nonflammable insulating and cooling medium for mineral oil. Such liquids have been developed and successfully used to eliminate the hazard of transformer fires. They have some obvious disadvantages. Most of them are semitoxic in nature, very active chemically, and when decomposed, the products are definitely toxic. The use of any liquid is in itself undesirable since it must be confined in a pressure vessel and the danger of a primary explosion cannot be eliminated completely.

The next step in the search for a safe transformer was the introduction of the ventilated dry-type transformer using Class *B* insulating materials. These transformers eliminate the explosion hazards due to materials within the transformer itself. The amount of organic material in the transformer is reduced to a point where it is less than the amount in motors and other rotating equipment which are used in similar locations. As a result, the fire hazard is very small. Only in the absence of overload protection of any kind with continued operation at high overloads is it possible to ignite and burn out the organic bonding materials permitted in Class *B* insulation. Such a fire is of low intensity and is easily extinguished. Millions of kilovolt-amperes of installed capacity in transformers of this type are in operation with, so far as known, a perfect human safety record.

Under some conditions, the use of ventilated dry-type transformers is not desirable. In areas containing quantities of inflammable materials or explosive dusts, there would be a safety hazard. Locations exposed to atmosphere containing high concentration of metallic dust or hygroscopic dust

Full text of paper 53-245, "Sealed Dry-Type Transformers Proved Safe By Test," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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would be undesirable because of the possibility of damage to the transformer itself. Ventilated dry-type transformers must be protected against excessive amounts of water vapor. In these and similar locations where the ultimate in safety is desired, the Class *H* sealed dry-type transformer finds its field of application.

The Class *H* sealed dry-type transformer which is the subject of the tests described here is built almost completely of nonorganic materials. The only exception is a small quantity of a semiorganic silicone varnish which is used to bind glass sliver insulation to the copper conductors, as a bond in the glass cloth insulating tubes, and as a coils coating.

OBJECT OF THE TESTS

THE TESTS to be described were designed to determine whether gross mistreatment of a standard sealed dry-type transformer could cause either a fire or an explosion, and to obtain quantitative data on just what possibility exists of either fire or explosion. Two types of tests were carried out. First, the transformer was subjected to extreme overloads under conditions adverse to the transformer as will be described. Second, a duplicate transformer was subjected to faults from coil to ground inside its case.

TEST MODEL

FOR TEST PURPOSES a standard sealed-type Class *H* insulated transformer built for generator grounding service was selected. The original transformer was rated 100 kva, 13,200 to 480 volts, single phase, 60 cycles. It was a 2-legged core-form transformer with concentric windings. In the test transformer, the coils on only one leg were used so that the transformer was rated 50 kva, 6,600 to 240 volts. The steel case was rectangular with inside dimensions of 30 by 42 inches by $51^1/_8$ inches high. When sealed, the tank, allowing for the displacement of the core and coils, contained 57,100 cubic inches of gas. Unlike the original transformer, the case was not welded shut but had a gasketed cover for convenience in testing. Four small glass-covered ports were placed in the case to permit visual inspection of the gap and of the coils during the test. Figure 1 is a view of the test transformer.

For the overload test, the transformer was dried out and sealed in an atmosphere of dry nitrogen at a gauge pressure of 1 pound per square inch. It then was connected for a standard load back temperature run. In the transformer directly over the top of the coils was placed a 1/2-inch rod gap, one end of which was grounded and the other end was taken out through a bushing. Throughout the period of the test, this gap was connected to a testing transformer through a rotary switch which closed a contact and flashed over the gap every 50 seconds. The case was provided with a pressure gauge and a bimetallic thermometer for reading the inside gas temperature. Also brought out of the case were two thermocouples, one for reading the core temperature, and one located on the low-voltage coil near its top. Readings were made every half hour during the test period.

OVERLOAD TESTS

THE SIMPLE PLAN of the test was to load the transformer at normal voltage and to increase the load in steps until failure. Each step of load was carried for an hour which is comparable to the time constant of the transformer. By this method, all the material in the transformer was brought up to a high temperature. Starting at 100-per-cent load for 1 hour, the transformer carried successively 150-per-cent load for 2 hours, 200-, 300-, and 400-per-cent load for 1 hour each. Ten minutes after the load was increased to 500 per cent, a soldered terminal on one of the cables used to connect the transformer to its power source melted off. The test was discontinued overnight and the terminal was replaced and brazed to the cable.

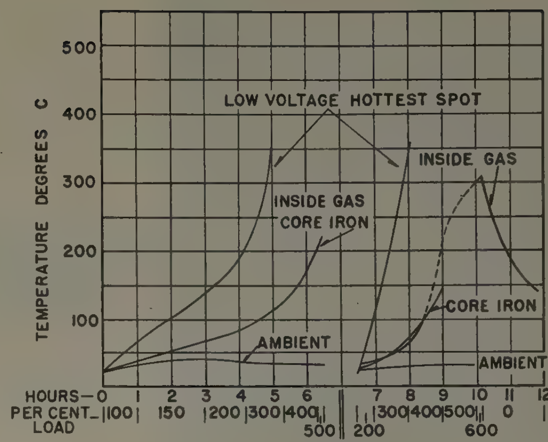

Figure 2. Temperature curves as a function of load and time after start of the overload test

On the following day, after carrying 200-per-cent load for 1/2 hour, the transformer was loaded at 300, 400, and 500 per cent of rated load for 1 hour each. Ten minutes after the load was increased to 600 per cent of rating, the transformer failed. Failure was detected by the load ammeter which dropped to zero. There was no visible disturbance in the transformer at the time. This concluded the test.

SOME OBSERVATIONS

THE GAP located in the gases arising from the coils was observed through a glass port during the entire period of the test and it continued to flashover every 50 seconds. Vapor first was detected arising from the winding after it had carried 300-per-cent load for 1/2 hour at which time the low-voltage hot-spot temperature was 350 degrees Centigrade. On the second day of the tests, the cover gaskets began to leak gas after 500-per-cent load had been carried for half an hour. At about this time, three sharp raps were heard inside the case. Later, it was discovered that this was the sound of three post-type porcelain lead supports falling to the bottom of the case. These were mounted by means of a metal insert held into the porcelain by solder which melted out when the inside gas temperature measured 270 degrees Centigrade. Twenty minutes after shutdown, solder on the cover was still molten. It came from the cable terminal which melted off on the first day of the test.

The measurements of pressures and temperatures are given in Table I. Both the core and winding thermocouples became inoperative before completion of the test. The temperature readings are plotted in the curves of Figure 2. Temperature rise of the high-voltage winding was measured

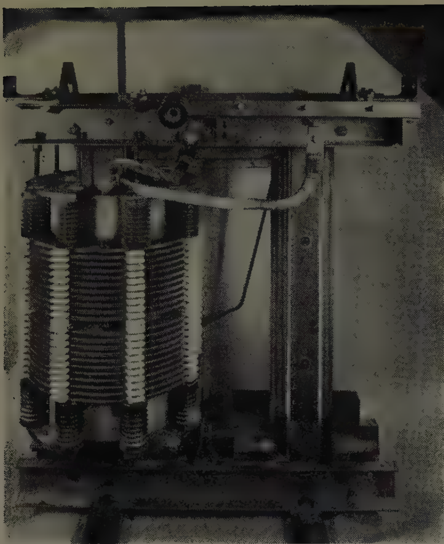

Figure 3. Core and coils after the overload test

3, 8, 29, 44, 59, and 74 minutes after shutdown. Corrected back to the time of shutdown, the high-voltage winding has a rise by resistance of 630 degrees centigrade, and a temperature of 660 degrees centigrade.

INSPECTION AFTER TEST

Following the overload test, the transformer was completely dismantled. Figure 3 shows the core and coil structure just after it was removed from the case. One of the four porcelain lead supports is seen still in place, although the insert has come out and is still bolted to the lead. Three other porcelains had dropped, leaving the metal inserts still bolted in place. Although these insulators had fallen, no shifting of the leads resulted.

Melted solder from the porcelain inserts had short-circuited the end frames to the core, but when this solder was pried loose, the end frame insulation still held 1,000 volts to the core. Most of the silicone had been driven off the high-voltage coil, but no other damage was done to the winding and it still would hold voltage. No turns were burned or displaced.

Cause of the failure was not discovered until the high-voltage coil was removed. The low-voltage coil was found in the condition shown in Figure 4 after the glass cloth tape was stripped down. On high overloads, the low-voltage winding, which is inside where it cannot radiate to the relatively cool tank wall, always runs hotter than the high-voltage coil. Failure of the low-voltage coil took place one turn from the top at the normal location of the hottest spot in the winding. It is probable that a turn-to-turn fault occurred, although the winding undoubtedly was near the fusion temperature of copper. The low-voltage winding burned open at the point of failure and the transformer dropped its load.

EVOLUTION OF GAS

At the start of the test, the transformer contained 33 cubic feet of nitrogen gas at a gauge pressure of 1 pound per square inch. Observations of gas temperature were taken throughout the test. If the mass of gas in the transformer had remained constant, then the absolute pressure would have been directly proportional to the temperature in degrees Kelvin. On Figure 5 are plotted the observed pressures and the calculated gauge pressures. After about 1/2 hour at 300-per-cent load, the test pressure begins to be greater than the calculated pressure, indicating an evolution of gas from the silicone varnish. The difference between the observed and calculated pressures (absolute) is a measure of the amount of gas driven out of the varnish. By this means, the gas evolved was calculated and plotted on Figure 6. These data are valid only up to 40 minutes before failure when the gaskets began to leak.

During the last 30 minutes before the tank began to leak there was evolved from the silicone 8.23 cubic feet of gas at an average rate of 0.275 cubic foot a minute. Table II shows the results of a gas analysis made before and after the overload test. It can be seen that 38.3 per cent of the gas contents of the transformer were combustible and consisted of hydrogen, methane, and carbon monoxide.

The test transformer coils were individually dipped in silicone varnish. After the coils were assembled on the core, that part of the core not inside the coils was sprayed with silicone. Rectangular copper strap covered with glass was used in the winding. These straps were coated with silicone varnish while the glass covering was applied. If the wire surface is calculated and added to the wound coil surface

Table I. Observed and Calculated Data

Load Per Cent	Hours From Start	Temperatures, Degrees Centigrade: Core	Low-Voltage Hot Spot	Inside Gas = Tc	Ambient	Gauge Pressure Pounds Per Square Inch: Measured	Calculated	Gas Evolved Cubic Feet
100	0	21	20	20	24	1.0	1.0	
100	1/2	28.5	41.5	25	27.5	1.6	1.3	
100	1	35.5	54.5	33	31.5	1.8	1.7	
150	1 1/2	41.5	84	42	35	2.3	2.2	
150	2	49.5	105	52	37.5	2.8	2.7	
150	2 1/2	57	117.5	58	37.5	3.2	3.1	
150	3	64.5	122.5	62.5	37.5	3.0		
200	3 1/2	71.8	161.5	74	38	3.8	3.9	
200	4	81.5	181.5	82	34.5	4.2	4.3	
300	4 1/2	94.5	267	99	34	5.0	5.2	
300	5		350	123		6.5	6.5	
400	5 1/2	140		164	33.5	10	8.7	1.8
400	6	168		198	33.5	13	10.5	3.3
500	6 1/2	220		230		17	12.2	5.9
200	6 1/2	28	28	29	26	3.2	1.5	3.5
200	7	36	100	48	27	4.5	2.5	3.5
300	7 1/2	49	255	79	28	5.7	4.1	2.7
300	8	67	333	106	29	8.0	5.6	3.9
400	8 1/2	97		158	30	11.0	8.4	3.8
400	9	145		200	30	13.5	10.6	3.8
500	9 1/2			270	30	25	14.4	12.0
500	10			300	30	23	16.0	
0	10 1/2			219	30	9	11.6	
0	11			190	30	5.8	10.1	
0	11 1/2			152	30	1.7	8.1	

Table II. Gas Analysis

Composition of Gas in Case, Per Cent	At Start	At Finish
Nitrogen (N_2)	99	58.9
Oxygen (O_2)	1	1.6
Carbon Dioxide (CO_2)		
Carbon Monoxide (CO)		6.4
Hydrogen (H_2)		25.0
Methane (CH_4)		6.9
Unsaturated Hydrocarbons		1.2

and to the surface of that portion of the core which is sprayed the figure should be a measure of the amount of silicone in the transformer.

Among the largest transformers of this type so far built are some rated 1,500 kva. A careful calculation made on the basis of the last paragraph indicates that this transformer would contain $5^1/_2$ times as much silicone as the test transformer discussed here. From this large transformer, if tested in a similar manner, a maximum evolution of $1^1/_2$ cubic feet of gas per minute might be expected. In such a transformer, the pressure would not rise to so high a value because while it would contain $5^1/_2$ times as much silicone, its tank would have a volume 8.8 times as great.

TESTS WITH FAULT TO GROUND

Following the overload test, a new coil was placed on the transformer. From the bottom of the high-voltage coil, a 1/2-inch rod gap was connected to ground with the gap close to the face of the coil. The transformer was sealed in dry nitrogen at a gauge pressure of 1 pound per square inch. It then carried load until the inside pressure raised to 3.5 pounds per square inch. While excited at normal voltage, a surge was applied to the high-voltage winding to flashover the gap inside. A power arc followed and was maintained for 85 cycles until cleared by the circuit breaker. The gauge pressure did not change during the fault. When the case was opened following the test, it was found that there had been a power arc from the bottom of the coil to ground completely around the circumference of the winding.

After the coil was repaired, a duplicate test was made with the transformer filled with air instead of nitrogen. Two impulses were applied. On the first test, the power fault following the impulse lasted for 3.97 seconds as measured by an oscillograph. In both cases, the fault current was about four times normal full-load current. Following the second test, the transformer no longer would hold excitation. When dismantled, it was found that four high-voltage sections had been burned in two. There was no change in gas pressure as a result of these faults.

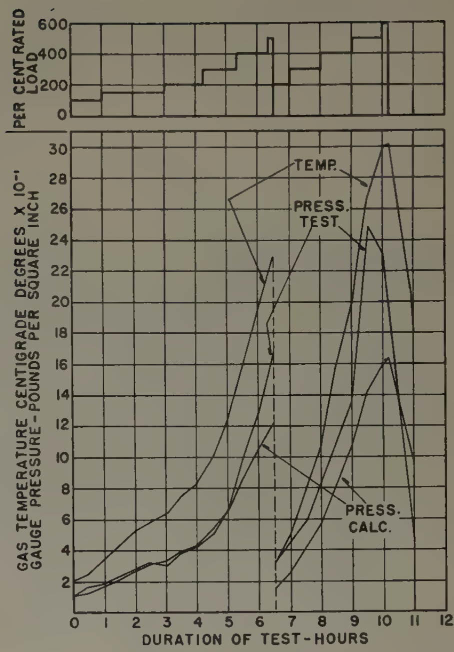

Figure 5. Calculated and observed gauge pressures as a function of load and time after start of the test

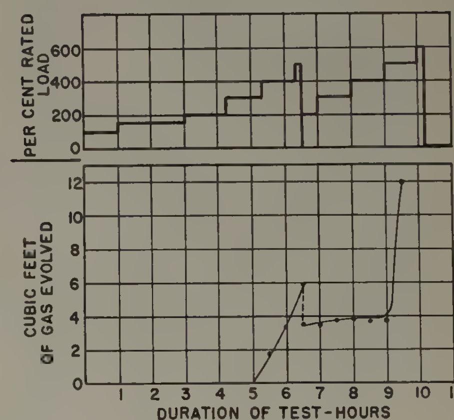

Figure 6. Gas evolved as a function of load and time after start of the test

Figure 4. Low-voltage coil failure

CONCLUSIONS

A standard sealed dry-type transformer with Class *H* insulation was overloaded to the point of failure. At the time of failure, the high-voltage copper had an average temperature of 660 degrees centigrade, and the low-voltage coil, which was inside the high, must have had a hot-spot temperature approaching the melting point of copper. While the silicone varnish was being decomposed, an electric arc was flashed every 50 seconds in the decomposition products which reached 310 degrees centigrade, but there was, nevertheless, neither a fire nor an explosion.

It is evident that the conditions of the test involve an extreme mistreatment which could not happen under any reasonable system of application. It is further evident that based on conditions of loading reasonably to be expected a completely sealed dry-type transformer, using the type of construction described, is safe for any application. Danger from fire and explosion is eliminated.

A Track-Laying Shuttle Car

J. W. BRAUNS

DURING THE PAST quarter century the introduction of mechanical mining has revolutionized the coal industry. As the revolution progressed, a bottleneck developed in the operation behind the loading machine. Transportation schemes in use 20 years ago could not move the coal away from the loader fast enough. In 1935 the idea was conceived of using rubber-tired tractor-trailer units to maintain a steady flow of coal from the loader to the secondary track system. These units proved efficient for gathering the coal, but occupied too much space. About 1939 a single-unit self-propelled shuttle car, basically the type being used today, was developed.

For the next 10 years shuttle-car design followed the original rubber-tired 4-wheeled pattern. In 1950, after careful review of shuttle-car performance during several years, General Electric introduced its track-laying car. The rubber-tired vehicles were not suited for wet mines. The small area of contact between the tire and the ground gave comparatively high ground pressure. As a result, these vehicles tended to dig ruts in the haulage ways and bog down in the soft bottoms. The track-laying design, with its larger ground contact area and lower pressure, has much less tendency to form ruts.

The car consists of a body with an adjustable discharge boom at the front end, a chain-driven conveyor running the length of the car, and two crawler-type tracks. It has a vertically mounted 500- to 600-foot capacity cable reel with a level-wind feature. A small hydraulic motor, operating in conjunction with a differential pressure valve, serves to keep correct cable tension for automatic spooling and unspooling. A 20-horsepower d-c series motor drives each track through a right-angle gear box plus a chain and sprocket arrangement. Automatically timed magnetic contactors provide three steps of acceleration. The control equipment is sealed type and control compartments are force ventilated where necessary. Steering is accomplished by braking one track in much the same way as a conventional crawler-type tractor. The traction motor on the side being braked is disconnected during braking. Clasp-type brakes, hydraulically controlled from valves at the operator's position and operating on a drum mounted on the traction motor shaft, are used. They are spring-set, fail-safe, and automatically apply if the power supply is interrupted. Hydraulic pressure is furnished by a pump with a high-capacity section for the discharge boom lift and a low-capacity section for the cable reel and brakes. The pump is driven by a 3-horsepower compound-wound d-c motor. The operator's compartment, located near the front of the car on the side opposite the cable reel, contains two cushioned seats, one for either direction of operation, plus all necessary controls. Within easy reach of the operator are levers for raising and lowering the adjustable boom and for 2-speed operation of the conveyor, a forward and reverse pedal, two steering levers, control and headlight switches, and a foot gong.

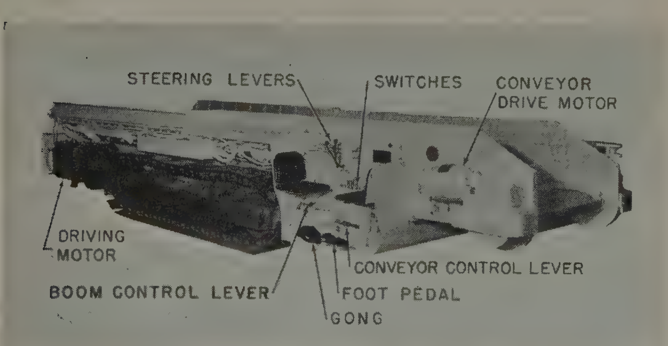

Figure 1. Oblique view of car from front end with principal control equipment identified

The car is highly maneuverable. By changing the braking force on one of the tracks, the operator can execute varying degrees of turns. If he locks one track by applying the brakes, the car actually will pivot about that track. This feature is particularly useful when operating behind a loading machine, as the loading end of the car may be moved from side to side merely by applying a slight amount of forward or reverse motion to the unlocked track.

The track carriages are pivoted to the car body on the rear or drive end and spring loaded at the front end by means of a torsion spring and knuckle. This allows the car to follow uneven mine bottoms and still give a smooth ride to the operator. It also reduces the body frame stresses which normally would occur if the carriage were firmly mounted at both ends to the car body. Furthermore, the track-laying design eliminates the need for wheel wells in the body, thus giving greater coal-carrying capacity and faster unloading. Two 5-horsepower gear reduction motors drive the conveyor chains. These are designed for two speeds—high speed for unloading into a mine car and low speed for unloading onto a conveyor belt.

Operation is simple and practically effortless. To move the car straight ahead, the operator presses the pedal in the direction he faces. To turn he operates the hand lever corresponding to the direction of the turn.

Experience to date indicates that this car is capable of working behind a mechanical loader or a continuous mining machine and moving with its burden over the toughest of working roadbeds, and that it offers a fast, efficient means to transfer coal from the working face to the secondary haulage system.

Digest of paper 53-366, "A Track-Laying Shuttle Car," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Middle Eastern District Meeting, Charleston, W. Va., September 29–October 1, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Split-Phase Currents as Generator Protection

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SPLIT-PHASE currents in multicircuit generator windings exist only because of necessary manufacturing tolerances or because of winding faults. This article attempts to set forth something of the nature of these split-phase currents and discusses the type of current transformers and relays which can be used to afford generator winding protection.

An internal fault in a multicircuit stator winding of an a-c generator will cause a current to flow between the parallel circuits of the winding and it is this characteristic which has been used for many years for the "split-phase" protection of generators. Such protection is simple, and experience has demonstrated that it is both reliable and effective.

A small circulating current between circuits is always present when the machines are in normal operation. This is known as the normal circulating current. It is due to manufacturing tolerances and is affected by load and by external faults. At full load it is somewhat greater than at no load, and both are likely to differ from the open circuit value.

An external fault causes transient and sustained modification of the split-phase current. In a generator without an amortisseur, a line fault causes a transient several times the normal split-phase current. This dies out at the rate of the armature time constant to a residual third harmonic current. In a generator with an amortisseur this transient is much less, a low-reactance complete amortisseur practically eliminates it.

Any fault in a generator is dangerous if it causes local heating sufficient to produce a fire hazard. If such a condition is allowed to develop until the fault involves ground or another phase, the normal ground or differential will clear the machine; but this may be too slow to prevent a fire or expensive damage. Split-phase protection is justified if it will detect a fault while the fault is still localized.

The most difficult fault to detect is a high-resistance joint that opens up and arcs, causing a fire in the coil end connections. Tests show that, regardless of the winding connection, split-phase currents of sufficient magnitude cannot be produced to give protection in time to prevent some damage.

Winding short-circuit faults are probably the greatest potential hazard in any machine and the potential difference between adjacent parts of a winding need not be high to cause extensive damage. A survey of the conductor in respect to its insulation from other adjoining conductors reveals that approximately half of the insulated surface is turn insulation and the other half coil insulation. Of this latter, about 60 per cent is in contact with the core or is adjacent to coils in another phase and this part of the conductor is all that is protected by ground and line-to-neutral differential relaying. Split-phase relaying is used then in an effort to provide protection for the other 70 per cent of the conductor where differential relaying is not effective. Split-phase relaying will be of particular advantage if it can be designed to detect a turn-to-turn fault which in itself will not cause extensive damage but which can do so if allowed to grow into a phase-to-phase or phase-to-ground fault. It can be shown that normal split-phase circulating current can be made small enough and that split-phase relaying can be made sensitive enough to detect such turn-to-turn faults whether the winding is connected alternate pole or adjacent pole.

The split-phase current is quite sensitive to faults in the rotating field coils; in fact too sensitive, as rotor coil faults that will cause no hazard to the machine will result in split-phase currents that will operate relays set to take care of turn faults in the stator. A short-circuited turn or two in a field coil is certain to cause an instantaneous surge of split-phase current in the event of external short circuit, reduced considerably, however, by the presence of an amortisseur winding. The split-phase relaying is not sensitive to an arcing open circuit in the field circuit.

Split-phase relaying for generators has been in use for many years but until comparatively recently it has consisted of standard differentially connected current transformers in combination with a percentage differential type of relay. Such a relay is not well suited to sensitive split-phase relaying because in order for it to be inoperative on external fault the slope either must be such that it is relatively insensitive at normal load current, or too sensitive at light loads.

The generator designer can estimate the probable normal circulating split-phase current of a machine and the increase in such current on a turn fault. Use then can be made of standard current transformers differentially connected; current transformers with special secondary windings to match the relay burden; or special single-core differential primary transformers, depending upon the sensitivity required.

With this last type of transformer a sensitive instantaneous type of relay can be used without risk of false tripping on external fault, especially if the machine has a low-impedance amortisseur. However, for most cases it appears best to use an induction-type relay of "very inverse" characteristic together with an instantaneous attachment for back-up. The instantaneous attachment should be set high enough so that it will just not trip on external fault.

Digest of paper 53-314, "Characteristics of Split-Phase Currents as a Source of Generator Protection," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Pacific General Meeting, Vancouver, British Columbia, Canada, September 1–4, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Block Diagram Analysis of Vacuum-Tube Circuits

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MANY AUTHORS OF textbooks on electronics begin their discussion of feedback amplifiers with the now-classic block diagram, from which they derive the general gain equation,

$$A' = \frac{A}{1-A\beta} \tag{1}$$

where A is the gain without feedback and β is the feedback fraction. In dealing with specific circuits, however, it is a common practice to write and solve the circuit equations. This article shows that amplifiers and oscillators can be analyzed from start to finish by block diagram methods, first developed for feedback control systems[1] and later applied to purely circuit problems.[2]

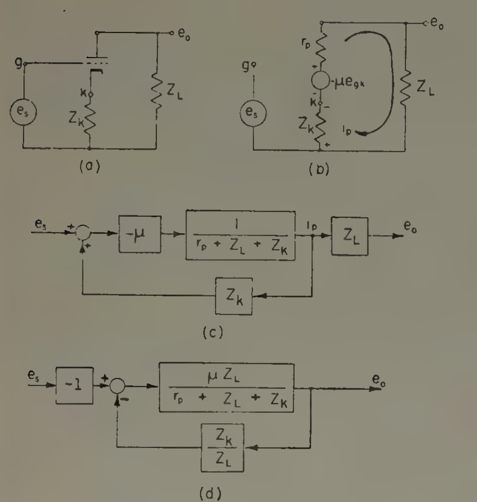

Figure 1. Amplifier with current feedback and block diagram solution

A typical example, an amplifier with current feedback from an element in the cathode circuit, is shown in Figure 1. In the equivalent circuit, Figure 1*b*, the tube is represented as a voltage generator in series with the plate resistance, and current is considered positive when leaving the plate terminal. With these sign conventions, the circuit equations are

$$e_{gk} = e_s + i_p Z_k \tag{2}$$

$$i_p = \frac{-\mu e_{gk}}{r_p + Z_L + Z_K} \tag{3}$$

and

$$e_o = i_p Z_L \tag{4}$$

as indicated in block form by Figure 1*c*. The next diagram, Figure 1*d*, is obtained by moving Z_L into the forward path and its reciprocal into the feedback path, and by moving the negative sign associated with the amplification factor to the left of the summing point. The large block in the forward path is now the gain without feedback, the block in the feedback path is the feedback fraction, and the (-1) indicates the sign change associated with a single stage of amplification.

A phase-shift oscillator and its block diagram are shown in Figure 2. When i_1 is small, the forward path is simply

$$A = \mu \frac{R_L}{r_p + R_L} \tag{5}$$

and the feedback path is a 3-section resistance-capacitance ladder network whose transfer function reduces to $(T = RC)$

$$\frac{e_{\text{out}}}{e_{\text{in}}} = \frac{T^3 s^3}{T^3 s^3 + 6T^2 s^2 + 5Ts + 1} \tag{6}$$

Routh's criterion gives the necessary condition for oscillation as $A \geqq 29$.

Block diagram methods are also applied to a resistance-capacitance amplifier stage without feedback, to feedback amplifiers including voltage and combined voltage-current feedback, and to a tuned-plate oscillator. The principal advantage of the block diagram method is the straightforward way in which the forward and feedback transfer functions are found, requiring no particular prescience or algebraic sleight-of-hand.

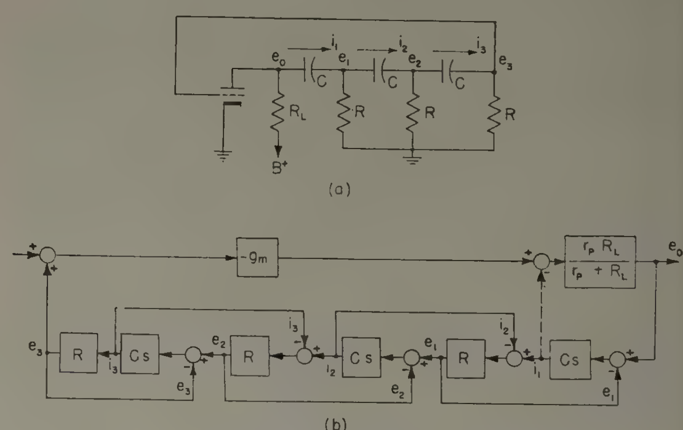

Figure 2. Phase-shift oscillator and block diagram

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Digest of paper 53-269, "Block Diagram Analysis of Vacuum-Tube Circuits," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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The Role of Fuses in Appliance Protection

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More complicated appliances, performing more functions automatically, connected to larger capacity circuits capable of delivering destructive power under fault conditions, increase markedly the need for electrical protection. Dual-element fuses are recommended to provide complete protection to motor-driven appliances. Appliances with little thermal capacity should be provided with extremely fast-blowing fuses where everything is done to decrease the time delay instead of attempting to build it into the fuse. However the manufacturers' time–current characteristics facilitate the selection of the proper fuse for a given appliance.

EVERY DAY the need for the electrical protection of appliances becomes more pronounced. This need not only is recognized by safety organizations such as the Underwriters' Laboratories but also by the appliance manufacturers. It is the direct outgrowth of more complicated appliances, performing more functions automatically, connected to larger capacity circuits capable of delivering devastating power under fault conditions.

For complete electrical protection the protector should be located at the point where the appliance is connected into its supply circuit and its time–current characteristic should match the safe time–current characteristic of the appliance. In many cases, from a practical consideration, it is necessary to make a compromise as to the location of the protector and as to its time–current characteristic, but in other instances the improper selection is made because the appliance designer did not fully appreciate the types and kinds of protectors available.

If the appliance is connected to the branch circuit with number *18* flexible cord, the most vulnerable spot probably is in the cord itself. The National Electrical Code assumes that the cord is protected by the branch circuit protection. Even on the 15-ampere circuits in common use today this is not the case and the condition will become even worse when 20-ampere circuits are used more extensively.

The joint committee of the Edison Electric Institute and the Fuse and Circuit-Breaker Sections of the National Electrical Manufacturers Association, working to develop the time–current characteristic of the ideal branch circuit protector, have established that a short-circuit current of 2,000 amperes flowing through a number *18* flexible cord will vaporize the cord completely if permitted to flow for 0.0078 to 0.0156 second. Even a 30-ampere plug fuse or Fustat will clear such a short circuit in 0.006 second, protecting the flexible cord. However, a 15-ampere branch circuit breaker requires more than 0.0156 second to operate at 2,000 amperes so that the cord is vaporized under these conditions when plugged into such a circuit. The situation is even worse on a 20-ampere circuit protected by a circuit breaker.

Since circuit breakers are commonly used to protect branch circuits, it is the responsibility of the appliance manufacturer to provide adequate protection or recommend additional protection at the convenience outlet. The ordinary attachment plug can be replaced by the fused attachment plug shown in Figure 1. It provides a convenient receptacle for 1/4-inch diameter fuses either 1 or $1^1/_4$ inches long. Since these fuses with fast-blowing characteristics are listed by the Underwriters' Laboratories in ratings from 1/200 ampere to 15 amperes and in slow-blowing types from 1/100 ampere to 7 amperes the fused attachment plug furnishes a relatively inexpensive means of adding electrical protection to the appliance without completely redesigning it.

One objection to the use of small dimension fuses for the protection of appliances is the danger of the user replacing the blown fuse with one of higher rating instead of trying to find the cause of the trouble. Also, slow-blowing fuses small enough to be used in fused attachment plugs in ratings larger than 7 amperes are not listed by the Underwriters' Laboratories. Both objections are overcome by the box-cover unit shown in Figure 2. It consists of a Fustat receptacle in series with a grounded receptacle mounted on a standard outlet box cover. By replacing the convenience outlet with the box-cover unit a fused receptacle of the proper size is provided for the appliance along with provision for grounding where desired. Due to the size-limiting

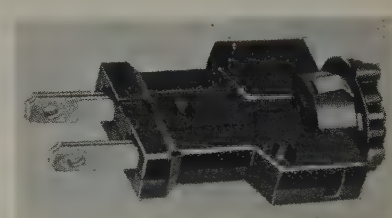

Figure 1. Attachment plug with fuses

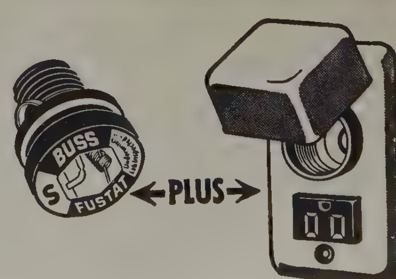

Figure 2. Box cover unit with Fustat

Full text of a conference paper presented at the AIEE Conference on Domestic Appliances, Louisville, Ky., April 22–24, 1953, and recommended for publication by the AIEE Committee on Domestic and Commercial Applications. Part III of a series.

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feature of the Fustat the danger of replacement with the wrong size fuse is eliminated. Also, the Fustat has slow-blowing characteristics so that the fuse will not be blown needlessly on harmless transient currents.

If the appliance manufacturer is not too concerned with the protection of his cord, he can move the fuse from the attachment plug or convenience outlet to the appliance itself. This permits him greater latitude in the selection of his fuse and fuse mounting. In addition to the relatively large National Electrical Code size fuses he can use small-dimension cartridge fuses listed by the Underwriters' Laboratories mounted in fuse blocks shown in Figure 3 and fuse holders in Figure 4.

The electrical characteristics of fuses suitable for the protection of appliances fall into two categories. The fuses are

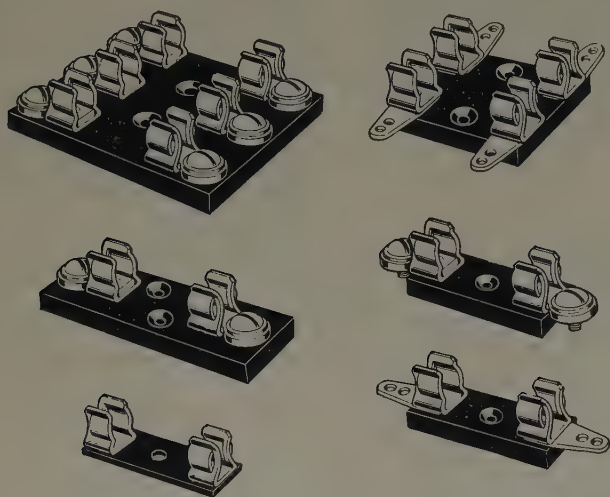


Figure 3. Fuse blocks for small dimension fuses

either fast or slow blowing. The fast-blowing or ordinary fuse consists of a fuse link, usually made of zinc, surrounded by air on the lower voltage fuses or with arc-quenching filler on the higher ones. Current flowing through the fuse generates heat in the link. At loads greater than its rating the heat generated raises the link temperature until the melting point of zinc is reached, at which point the link melts, opening the circuit. The time–current characteristic of such a fuse is a smooth curve without any points of inflection. Since the link has little thermal capacity once the current exceeds its rating, the fuse blows rapidly with little time delay.

Some time delay can be built into the zinc link fuse by increasing its thermal capacity with lag plates or wide sections but the amount of time delay so obtained is inadequate for the protection of motor-driven appliances. For such applications the dual-element fuse is recommended. One type is shown in Figure 5.

In the Code cartridge sizes, the dual-element fuse consists of a short-circuiting strip surrounded by arc-quenching filler in each end with a thermal overload device in the center. Current flowing through the fuse generates heat in the short-circuiting strips. At the lower overloads, where there is time for thermal conduction,

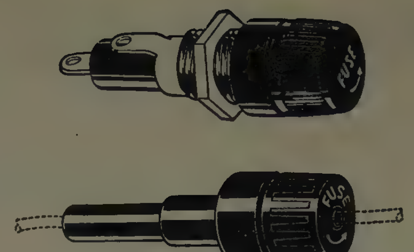


Figure 4. Fuse holders for small dimension fuses

the heat is conducted to the thermal overload device in the center of the fuse raising its temperature to 280 degrees Fahrenheit at which point the fusible alloy melts permitting the interrupter to move mechanically under spring tension, opening the circuit. This takes appreciable time.

At the higher overloads, where there is not sufficient time for thermal conduction, the heat generated in the reduced sections of the short-circuiting strips raises their temperatures to their melting point causing them to operate like ordinary fast-acting fuses. By using copper and copper alloys for the short-circuiting strips the mass can be reduced to less than that of the zinc link used in ordinary one-time fuses. This permits superior short-circuit performance even though the available space for short circuit is reduced materially.

A comparison of the time–current characteristics of a 100-ampere 250-volt one-time and dual-element fuse, as shown in Figure 6, more clearly illustrates the greatly increased time delay possible with the dual-element type of fuse at the lower, useful overloads with faster action under short-circuit conditions. Both are listed by the Underwriters' Laboratories so both are designed to carry 110 amperes indefinitely and both will open at 135 amperes within 2 hours. From this common point the two curves diverge widely. At 200-per-cent load or 200 amperes the one-time fuse requires 28 seconds to blow whereas the dual-element fuse will hold the same load for 160 seconds. At 300 amperes the times are 7 and 48 seconds respectively. At 500 per cent the one-time fuse is blowing in 1.8 seconds and the dual-element fuse in 12.8 seconds. At 1,000 amperes the dual-element fuse still has approximately 20 times the opening time of the ordinary fuse, the times being 0.36 second for the one-time and 7.6 seconds for the dual-element fuse. However, by 2,500 amperes the fast-acting short-circuiting strips of the dual-element fuse are coming into

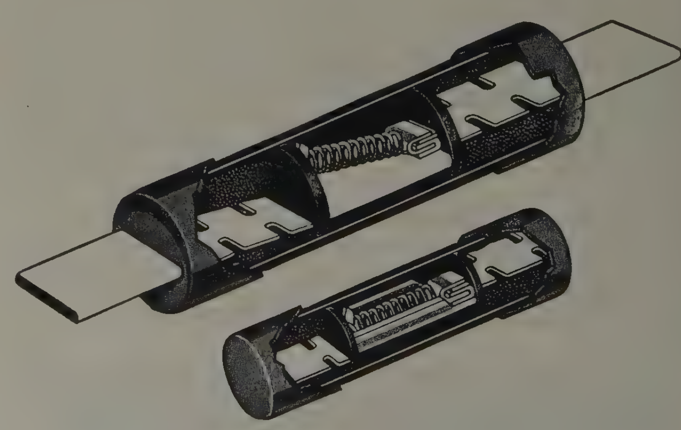
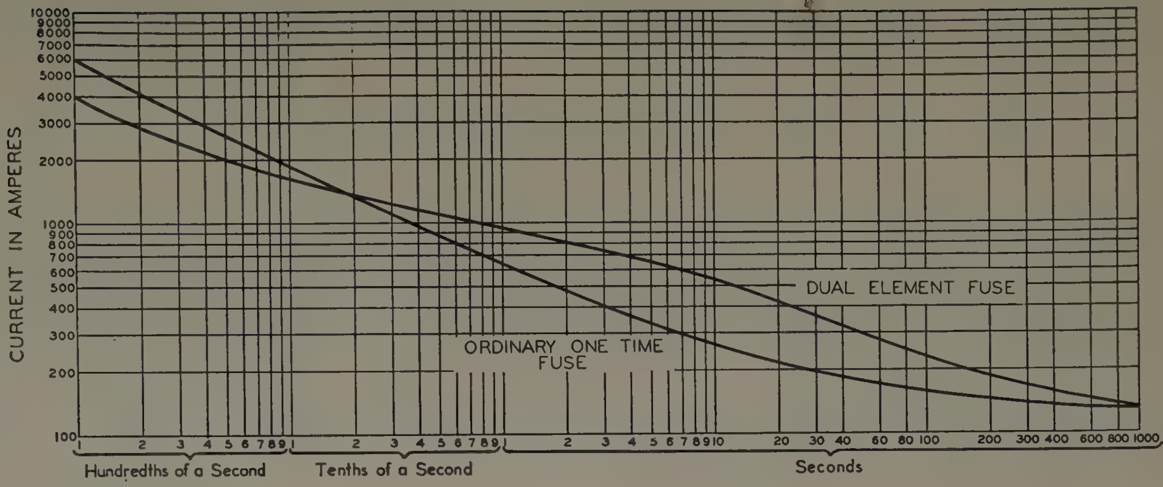


Figure 5. Cutaway showing construction of dual-element fuse

Figure 6. Time–current characteristic of 100-ampere 250-volt fuse



play causing the dual-element fuse to open in half the time of the one-time fuse, the times being 0.028 and 0.056 second.

In other words the dual-element fuse has greatly increased time delay at the useful loads up to 1,000 per cent but at higher loads, approaching short circuit, where fast clearing is desirable it has extremely fast operation. When applied to the problem of the protection of electric appliances it means that the rating of the dual-element fuse can be selected approximately equal to the rating of the appliance even if the appliance employs motors or solenoids producing heavy inrush currents during the operating cycle. The ordinary one-time fuse rating must be selected several times the rating of such appliances to prevent its blowing during the cycle. If the appliance draws a steady load without surges the ratings of the dual-element and ordinary fuses can be the same and little is to be gained by using the dual-element fuse.

By selecting the rating of the dual-element fuse equal to the rating of the motor-driven appliance complete protection without needless blowing becomes a reality. Since the time–current characteristic of the dual-element fuse has the same shape as the safe-time–current characteristic of the motor an overload which is continued long enough will cause the dual-element fuse to open before the motor is damaged. If the motor is controlled and protected by a motor starter with thermal overload relays, the dual-element fuses in the disconnect switch provide back-up protection to the thermal overload relays. On the other hand, if the motor in the appliance is too small or if space does not permit the use of the motor starter the dual-element fuse in either the National Electrical Code or small dimensional size provides overload as well as short-circuit protection to the appliance.

On the larger appliances the reduction in fuse rating possible with the dual-element fuse produces another advantage. The reduction in fuse rating permits, in many cases, the use of a smaller switch at lower cost. Such an installation is satisfactory because many switch manufacturers have obtained Underwriters' Laboratories listing of their switches at an increased horsepower rating with dual-element fuses. Hence, the smaller switch with the dual-element fuses provides a more compact installation at lower cost.

For this reason dual-element fuses mounted in suitable fuse blocks or fuse holders provide complete protection to motor-driven appliances. They also can be used to protect appliances with steady loads but there is little to recommend their use over ordinary one-time fuses. Appliances with little thermal capacity, such as instruments, require extremely fast-blowing fuses where everything is done to decrease the time delay instead of trying to build it into the fuse. The fuse manufacturers have available time–current characteristics of the various types of fuses they manufacture which makes the selection of the proper fuse for a given appliance a relatively simple matter.

Velocity of Light Exceeded

A research engineer in the Naval Research Laboratory, Washington, D. C., Harold J. Peake, has succeeded in achieving a velocity greater than the velocity of light.

Photographic recordings have been made of a spot of light that passed across a cathode-ray tube at a velocity of nearly 202,000 miles per second. So far as is known, this is the highest cathode-ray velocity that has ever been recorded.

The trace velocity on a cathode-ray tube is proportional to the rate of change of the applied deflection signal voltage. In attaining a trace velocity of 202,000 miles per second, the applied signal changes at a rate of 3 million volts in a millionth of a second.

Mr. Peake pointed out that no material particles are involved when the velocity of light is exceeded in this manner. It is not, therefore, in violation of Einstein's theory of relativistic mass increase, since the trace velocity is really a phase velocity which has no theoretical or practical limit.

The oscillographic and photographic combination instrument developed by the Navy to record very rapid voltage changes permits the observation of phenomena of relatively brief duration. This instrument, called a time microscope, makes possible the study of electrical events which occur in one millionth of a millionth of a second.

The Zero-Flux Current Transformer

A. HOBSON

THE VOLTAGE which must be induced in the secondary winding of a current transformer, in order to overcome the impedance of the circuit, gives rise to a corresponding magnetic flux in the core. It is the ampere turns needed to maintain the flux which constitute the error of the transformer.

If the voltage could be supplied from another source the core flux would be zero, and the transformer would operate without either ratio or phase angle error. In other words, it no longer would be obliged to supply energy and could concentrate on its task of measuring current.

The voltage may be obtained from a second current transformer called a compensator; Figure 1 shows one arrangement for a 500/5-ampere ring transformer. The 1-ohm resistance represents the lumped impedance of the whole secondary circuit.

The secondary and compensator circuits each carry 5 amperes, and the voltage drop across R is reproduced in coil B as a boost in the secondary circuit. When R is 1 ohm all the necessary voltage is supplied by the compensator and the main core flux is zero. As the line current changes all the currents and voltages vary in proportion, so that in theory the compensation stays correct for any current. In practice the output of the compensator is not quite linear and the current transformer has errors, which, however, are very small compared with those of a plain transformer.

The better a transformer is to begin with the more easily and effectively it may be compensated. For this reason the method is particularly suited to the "perfecting" of reasonably good current transformers such as are used in test rooms and laboratories.

Table I shows the improvement made on a small transformer with a Mumetal core. At 5 volt-amperes the errors almost disappeared when compensation was applied. Even at 25 volt-amperes, with the compensator core flux approaching saturation, the benefit was very striking.

In this way compensated high-precision transformers now may be constructed which are much smaller and less costly than hitherto, particularly when they are required to work over a small range of burdens. A further advantage is that the errors change very little with the operating frequency.

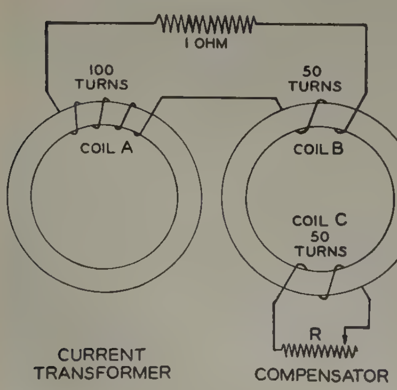


Figure 1. 500/5 compensated transformer

Table I. Ring-Type Current Transformer, 500 Ampere Turns

Mumetal Core 3 Inches Total Depth, 3 Inches Inside Diameter, 4 1/2 Inches Outside Diameter

	Plain Transformer		Compensated	
Nominal Second Amperes	Ratio Error, Per Cent	Phase Angle, Minutes	Ratio Error, Per Cent	Phase Angle, Minutes
5-Volt-Ampere Burden				
5	−0.042	+ 4.0	0.000	0.00
3	−0 053	+ 4.9	0.000	0.00
1	−0.068	+ 5.6	+0.001	+0.04
0.5	−0.077	+ 7.3	+0.002	+0.06
25-Volt-Ampere Burden				
5	−0.297	+ 6.8	+0.005	0.00
3	−0.320	+ 8.1	+0.003	0.00
1	−0.318	+15.7	+0.013	+0.21
0.5	−0.273	+19.2	+0.021	+0.35

Table II. 20/5-Ampere Bushing Transformer

Two Cores, One Mumetal, One Silicon-Iron; Each Core 4 Inches Deep, 5 Inches Inside Diameter, 7 Inches Outside Diameter

	Plain Transformer		With Triple Frequency and Compensation	
Nominal Second Amperes	Ratio Error, Per Cent	Phase Angle, Minutes	Ratio Error, Per Cent	Phase Angle, Minutes
2.5-Volt-Ampere Burden				
5	Off Scale		+0.10	+ 5
3	Off Scale		0	+ 4
1	Off Scale		+0.10	+18
0.5	Off Scale		−0.17	+28

By itself the method extends the scope of this type of transformer very considerably. However, the compensator output can be made much more linear if its core is rendered orthomagnetic by applying triple-frequency auxiliary excitation. When this is done still more striking figures are obtainable.

Table II gives the results on a 20/5-ampere transformer. With normal design its errors were too large to be measured using a test equipment which had limits of 5 per cent ratio and 250 minutes phase angle.

The compensator had only two turns, and therefore was working on 10 ampere turns. Of these about 5 ampere turns were lost in magnetization, the working flux density being about 35,000 lines per square inch.

For equal performance with a plain design this transformer would have to be about 50 feet long, using a solid Mumetal core weighing more than 1 ton.

Digest of paper **53-194**, "The Zero-Flux Current Transformer," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Southern District Meeting, Louisville, Ky., April 22–24, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Quick Methods for Evaluating Closed-Loop Poles

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IT IS GENERALLY necessary to know the closed-loop poles of a feedback control system in order to determine completely its time response. Although the peak overshoot and rise time for a step input can be estimated readily from the closed-loop frequency response of the system, such low-frequency effects as tails in the step response, the settling time of the ramp response, and so on, can be determined best from the values of the closed-loop poles.

However, the evaluation of the closed-loop poles up to now has been very difficult because it essentially requires the factoring of a polynomial of high order. Various numerical techniques have been used, but they are long and tedious. Evans' Root-Locus Method has facilitated greatly this evaluation, but it is still quite cumbersome. The use of these methods in the synthesis of feedback control systems has been quite limited, not only because of the excessive labor they require but, more important, because they do not yield any simple relations between the values of the closed-loop poles and the frequency-response plots of the system. In fact, there has been a tendency by those who employ such techniques to disregard utterly the frequency-response approach and to perform synthesis entirely in terms of the values of the poles and zeros of the system. The resultant synthesis procedures are quite cumbersome and often do not even yield desirable systems, because of the excessively limiting assumptions required.

On the other hand, the values of the closed-loop poles can be calculated quite simply from the open-loop function $G(s)$ of the system. Define the crossover frequency ω_c as the frequency where the magnitude asymptote of $G(s)$ is unity, which is roughly equal to the closed-loop resonant frequency. The closed-loop poles are roughly equal to:

(*a*) the zero of $G(s)$ below the crossover frequency ω_c
(*b*) the poles of $G(s)$ above ω_c
(*c*) plus, the pole $-\omega_c$

The actual values of the poles are shifted somewhat from these approximate values, the amount of shift being small for poles distant from ω_c and being large for poles near ω_c.

For a pole distant from ω_c the amount of shift can be evaluated easily by numerical reiteration. Designate s_1 as an approximate pole described in (*a*) or (*b*) above, and δ_1 as the shift of the actual pole from the approximate pole. Factor $(s-s_1)$ from $G(s)$. At the actual closed-loop pole, $(s-s_1)$ is equal to the shift δ_1 and $G(s)$ must equal -1. Thus,

$$\delta_1 = -/(s-s_1)/G, \quad \text{for } (a)$$
$$\delta_1 = -/(s-s_1)G, \quad \text{for } (b)$$

These equations are exact if $G(s)$ is evaluated at the actual pole, and are usually closely approximated if $G(s)$ is evaluated near to that pole. Hence, if the shift δ_1 is small, it may be computed by evaluating the equations at the approximate pole, and successively re-evaluating them at the new approximations to the pole thus obtained.

A graphical method may be used to evaluate any of the poles, but is not quite as simple to apply as the numerical-reiteration method. It employs plots which are generalizations of the standard plots of phase and log magnitude versus log frequency, now used in the frequency-response analysis of feedback control systems.

The poles near the crossover frequency are very important, since they determine build-up time and peak overshoot for a step input; but it generally is not necessary to evaluate them, because these characteristics of the step input usually may be estimated quite accurately from frequency-response plots. It is the low-frequency poles which must be evaluated, and these usually can be obtained by the numerical-reiteration method.

As an example of the use of this knowledge of closed-loop poles in synthesis, consider the addition of an integral network to a system, to increase its velocity constant. Frequency-response analysis shows that, for adequate stability, the upper break-frequency of the integral network must be set a significant interval below the system resonant frequency. On the other hand, the integral network produces a closed-loop pole, the magnitude of which is roughly equal to the upper break-frequency of the network. This pole adds a tail to the system step-response, having a time constant equal to the reciprocal of the magnitude of the pole; and in the ramp response this pole "integrates out" the steady-state error along an exponential curve with the same time constant. For fast settling, this time constant must be small, which requires that the poles, and likewise the upper break-frequency of the integral network, be large. Thus, optimum design of the network requires a compromise between stability, shown by the peaking of the output-versus-input frequency response, and settling time of the ramp and step responses, shown by the closed-loop pole produced by the integral network.

Thus, the analysis of feedback control systems in terms of its closed-loop poles should be considered as a supplement to the standard frequency-response approach rather than a substitute for it. Theoretically, the time response of a system can be calculated from either the values of the poles and zeros of the system or from a complete frequency-response plot. However, there are certain characteristics of the time response that can be obtained most simply from the frequency response and there are others that can be obtained most simply from the values of the closed-loop poles.

Digest of paper 53-42, "Quick Methods for Evaluating the Closed-Loop Poles of Feedback Control Systems," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Silver-Coated Joints of Aluminum Conductors

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THE EXPANDING facilities for the production of aluminum, coupled with its advantages of light weight and low cost, indicate strongly that aluminum will occupy a position of increasing importance in the electrical industry. To meet the high standards of performance being maintained with electrical joints in modern switchgear, a new process has been developed for the silver plating of aluminum. By replacing the aluminum surface in the contact area with a silver surface, the detrimental effects of the much discussed aluminum-oxide surface film can be eliminated. In this manner the admirable bulk characteristics of aluminum and the established excellence of silver surfaces as electric contacts can be combined in a reliable bus or connection bar.

With copper conductors, experience has shown that silver surfacing of the joints is necessary to good operating continuity and to a minimum of maintenance. With aluminum conductors, the benefits of silver plating appear to be even more decisive, apparently because, in the temperature range under consideration, the electrical resistance of an aluminum surface in contact with air rises much more rapidly and to higher values than for a copper surface. The superior performance of silver-plated aluminum joints in comparison with unplated aluminum joints of the same construction is shown in Figure 1.

In developing the silver-plating process, many thousands of sample bars were subjected to evaluation tests including the following: (1) bonding strength between silver plate and aluminum at room temperature; (2) freedom from blistering at high temperature; (3) freedom from porosity; (4) protection against corrosion in humidity and salt spray; (5) ability to carry high momentary currents; (6) ability to withstand short-circuit forces; (7) ability to withstand severe overheating by current overload; and (8) stability of performance on long-time cycling heat run. The conclusions follow.

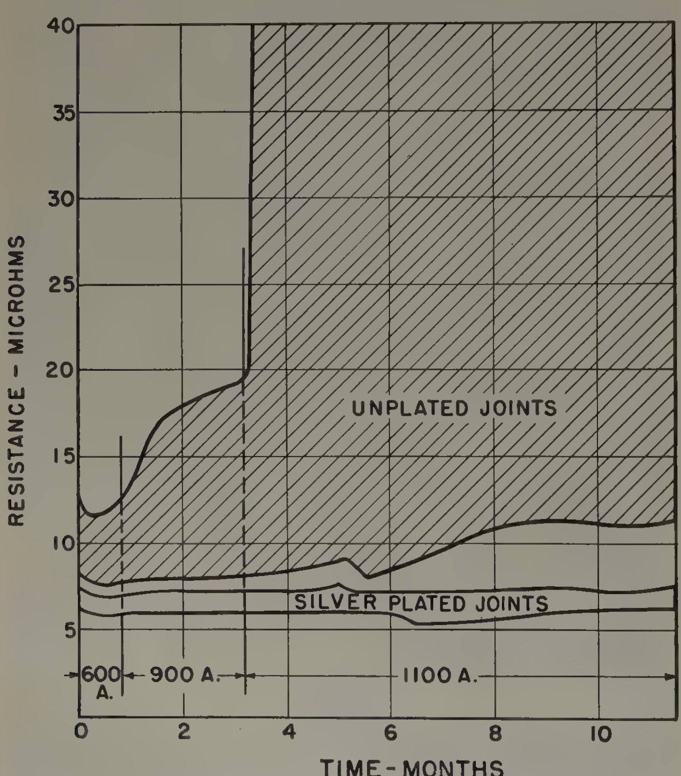

Figure 1. Superior stability and current-carrying capacity of silver-plated aluminum joints

1. A new process for silver-plating aluminum has been developed and is being used to eliminate joint failures which otherwise could be caused by the high-resistance aluminum-oxide film.

2. The advantage of silver is that its contact resistance, if raised by filming, characteristically decreases in value during normal operation. The basic reason is that silver is a noble metal, and as such tends to return to the metallic state when heated. In contrast, copper and aluminum tend to film more rapidly at elevated temperatures and to run away thermally.

3. Because many joints must be made between copper and aluminum conductors, addition of the silver plate does not introduce a new corrosion problem. Instead it shifts corrosion away from the contact surfaces to a region where it could progress to an exaggerated stage with little effect on performance.

4. Extensive endurance tests under high-humidity conditions have shown that greasing after silver plating, as has been standard practice in the past, solves whatever minor corrosion problem may exist with aluminum-to-aluminum and aluminum-to-copper joints in the great bulk of switchgear applications.

5. A similar set of endurance tests under salt-spray conditions has shown that an envelope configuration of silver plate, plus zinc-chromate grease and paint, provides highly stable performance.

6. The bond between the silver plate and the aluminum has been found to be stronger than either of the two metals.

7. On high-current test the silver-plated aluminum joints have remained undamaged at temperatures so high that the aluminum bars sagged because of their own weight.

8. On a 1-year cycling heat run, no silver-plated aluminum joint increased its contact resistance significantly. Even if carefully cleaned under oil and greased, all unplated aluminum joints exhibited varying degrees of rising resistance and temperature.

Digest of paper 53-104, "Performance of Electrical Joints Utilizing New Silver Coating on Aluminum Conductors," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953, and represented at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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The Operation of Outdoor Oil Circuit Breakers Under Low Ambient Temperatures

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MEMBER AIEE

The materials used in tank-type oil circuit breakers, the predominate outdoor type, and the effects that low ambient temperatures have upon their performance are examined. Conclusions are presented indicating that low ambient temperatures require special consideration even with modern outdoor oil circuit breakers, but further study is still needed.

FOR A GOOD MANY YEARS within the boundaries of the United States outdoor oil circuit breakers have been operated year in and year out under normal extremes of temperature with only minor consideration having been given to the effects of low ambient temperatures on their performance or the service expected from them. Generally speaking this practice has not led to major difficulties and performance has been acceptable. However, it is felt that the matter should have more consideration and further study in view of the expansion of transmission and subtransmission voltage systems in areas where low ambient temperatures are more frequently encountered.

These areas are best outlined by reviewing data which have been obtained from the United States Weather Bureau and which for ready reference have been plotted on Figures 1 and 2. Together they show that the lowest temperatures occur over an area along the Canadian border and in Idaho, Montana, North and South Dakota, and Minnesota.

The major factor in the operation of the breakers under low ambient conditions concerns the question of whether their performance will be affected and seriously modified. Since variations in performance due to low ambient temperatures are the direct results of the effects that these temperatures have on the materials used in their construction,

Condensed text of paper 53-232, "Considerations in the Operation of Outdoor Oil Circuit Breakers Under Low Ambient Temperatures," recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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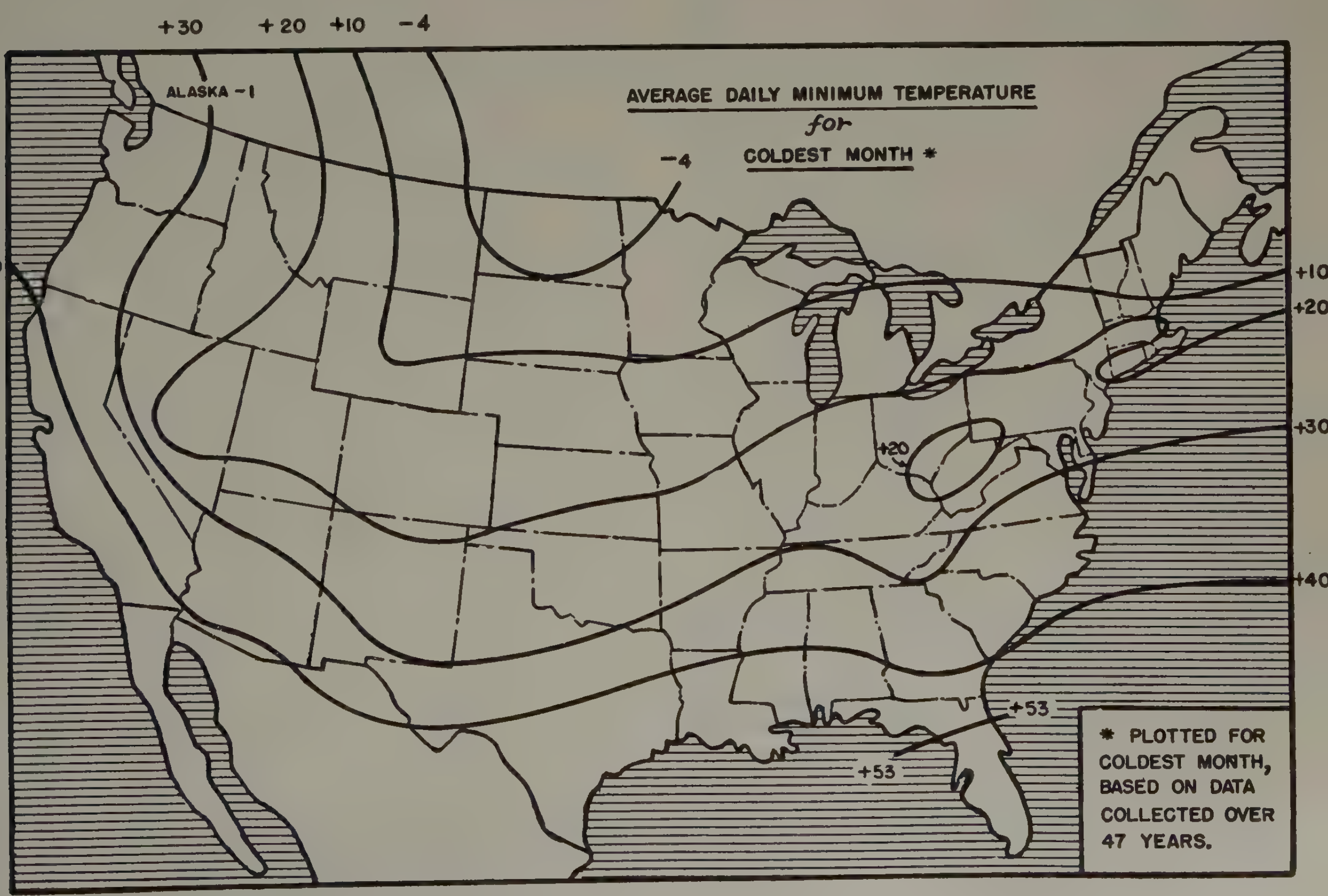
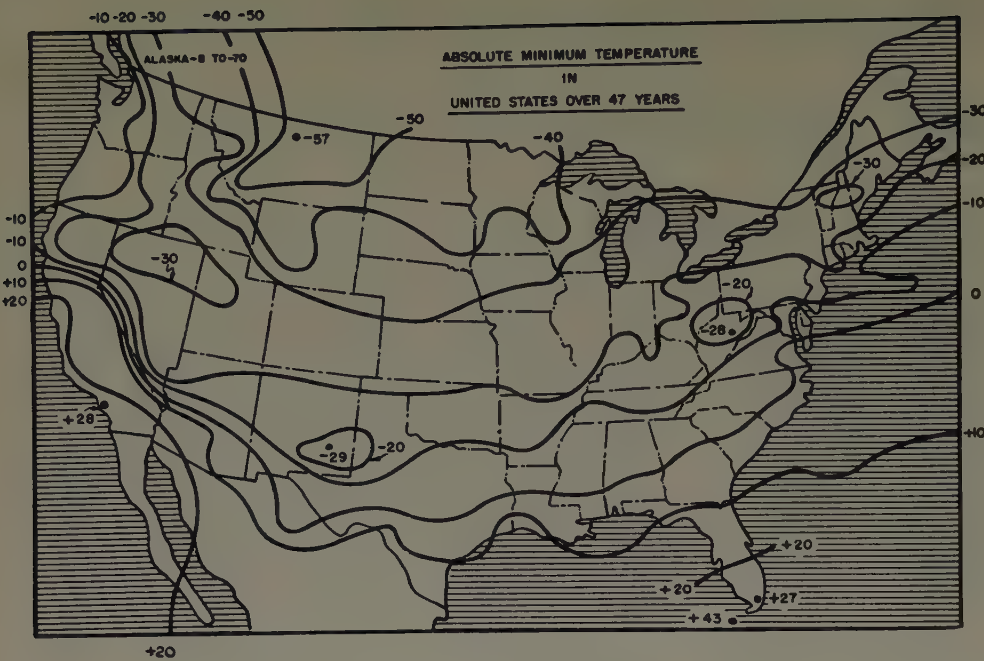


Figure 1. Record of average daily minimum temperature in degrees Fahrenheit for the coldest month



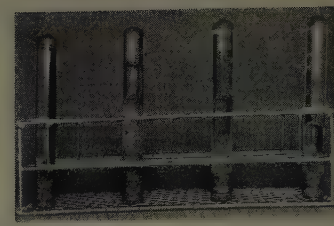


Figure 2 (left). Record of absolute minimum temperature in degrees Fahrenheit based on data collected over 47 years. Figure 4 (above). Graphical representation of changes in viscosity for General Electric number 10C oil. Positions of air bubbles indicate the time required to travel from the bottom position for room temperature, 0, −25, and −50 degrees centigrade left to right, respectively

it is reasonable to study these materials and the effects that low temperatures have on them.

EFFECT OF LOW AMBIENT TEMPERATURES ON THE MATERIALS USED IN OIL CIRCUIT BREAKERS

Many different kinds of materials are utilized in the design and manufacture of oil circuit breakers. Generally speaking, they can be grouped as insulation materials and metals. This section will review each of the various materials under these general classifications, noting the information that is available on their characteristics at low ambients. In some cases, this is very little.

Oil. Outdoor circuit breakers have used several kinds of insulating oil in the last 30 years, but the general practice today is to use a low-pour-point oil of which General Electric number *10C* is representative. Data will be referred to this oil as it is generally agreed that the superseded kinds of oil are not as satisfactory for outdoor use and therefore should be replaced.

Dielectric Strength. Temperature has little effect on the dielectric strength of dry clean oil, but the effect may become quite noticeable with oil in normal service which will usually contain a certain amount of moisture.[1]

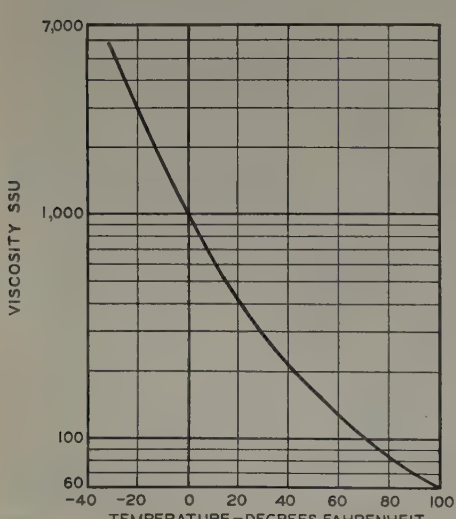


Figure 3. Viscosity coefficient for various temperatures using General Electric number 10C circuit breaker oil

Viscosity and Pour Point. Breaker and transformer oil in common use is characterized by listing it with a pour point of −40 degrees centigrade. However, this does not mean that it can be used successfully at this temperature, because long before that point has been reached the fluid properties have been so affected that both the motion of contact parts and oil flow for interruption have been modified enough to compromise performance.

The change in viscosity coefficient with temperature is shown in Figure 3. The changes in the oil with temperature are seen more graphically in Figure 4. Sealed test tubes were chilled to varying temperatures. Then all of them were inverted at the same time, and a photographic record made of the positions of the air bubbles in each of the tubes when the first one had reached the top.

The widely different positions indicate the changes in consistency of the oil for room temperature, 0, −25, and −50 degrees centigrade.

Solubility of Water in 10C Oil. The solubility of water in *10C* oil drops very rapidly as the temperature is lowered. For example, at 30 degrees centigrade normal oil holds in solution 85 parts per million of water, while at −30 degrees centigrade it will hold only 10 parts per million. This means that the remaining water will separate out as droplets and could be absorbed by any fibrous material with which it came into contact. If so, the dielectric strength of that material would be lowered.

Air. The dielectric strength of air around the external bushing porcelains is essentially unchanged at −40 degrees centigrade.

Molded Plastics. In general, the impact strength and elongation decrease with lowering temperature while the tensile strength and modulus of elasticity increase.[2] High-impact phenolics show a much more rapid change. The

general-purpose phenolics over a temperature range of +40 to −40 degrees centigrade show changes in these characteristics of 2 to 3 per cent, while the high-impact phenolics change from 25 to 40 per cent.

Laminated Plastics. Very little data are available on the effect of temperature on these materials. No adverse results have been experienced so it would appear that these materials are affected little by temperature. The more porous materials such as fiber, which may have a large content of water, may have their strength reduced if this water freezes and the material becomes more brittle.

Rubberlike Materials. These materials which are used quite generally for gaskets, oil seals, buffers, and so forth, are affected variously by temperature changes. Some still will retain their resiliency down to −40 degrees centigrade, but others will lose all of the properties which caused their original selection.

Porcelain. The dielectric strength at −40 degrees centigrade is higher than the strength at 25 degrees centigrade by a factor of 2 to 3. The resistivity at −40 degrees centigrade is less than the resistivity at 25 degrees centigrade by the first power of 10. The dielectric constant at −40 degrees centigrade is about 10 per cent less than at 25 degrees centigrade. The power factor increases about 30 times over the same range.

Ferrous Metals. All ferritic steels show a transition from ductile to brittle behavior with drop of temperature. The transition temperature depends on the composition, heat treatment, microstructure, grain size, and other factors. In some cases the transition temperatures may be within the low ambient temperatures being considered.

Austenitic stainless steels have notch toughness which remains unchanged at low temperatures.

Low and medium carbon steels carefully selected and properly treated can be used as low as −40 degrees centigrade.

Welding affects the properties of the base metal in the vicinity of the weld and must be used with caution in low-temperature applications involving shock loading. The weld and base material must be carefully selected and proper heat treatment must be provided.

Nonferrous Metals. These materials, such as copper and aluminum and their alloys which are used in circuit breakers, do not exhibit the transition that ferrous materials do, and, therefore, changes due to temperature variations are negligible. The impact strength of aluminum castings and annealed copper are unchanged over ranges of +70 to −112 degrees centigrade.

Paint and Corrosion Resistant Finishes. Unaffected.

EFFECT OF LOW AMBIENT TEMPERATURES ON OIL CIRCUIT BREAKER PERFORMANCE

In so far as low ambient temperatures affect the materials used in circuit breakers so will the performance be affected. Therefore, with the review that has been made, it is possible to relate these material changes to the performance characteristics that they affect.

Insulation Level. Oil, air, and solid insulations are utilized in an oil circuit breaker to obtain the required insulation strength. Since the dielectric strength of these materials is not affected by low ambient temperatures neither is the performance characteristic.

Current-Carrying Capacity. Operating temperature limits are set up to prevent changes in the condition of materials and parts, which would affect their performance or life. These limits are based on an allowable temperature rise above a maximum ambient temperature. Since the final temperature of the part is the deciding factor, low ambient temperatures provide an opportunity to increase the load-carrying capacity because, even though the temperature rise will be higher, the final temperature will not be exceeded. In other words, if the final temperature of the contacts can be 70 degrees centigrade which is based on a 30-degree centigrade rise over a 40-degree centigrade ambient, then it is reasonable to assume that the contacts can be operated at a higher rise when the ambient is less than 40 degrees centigrade.

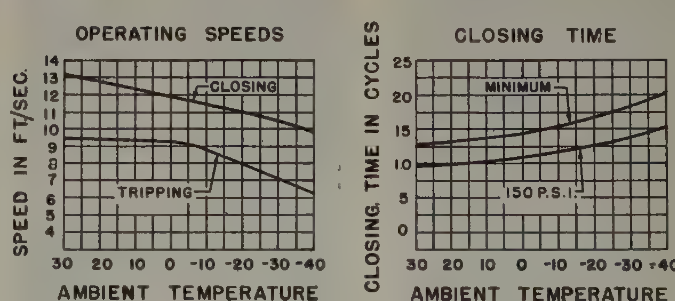
To check this conclusion, a survey was made of circuit breaker heat run data for the purpose of determining the current which could be carried when the ambient was below 40 degrees centigrade. From these data, an equation was developed to predict the current-carrying ability.

As an example of how it would be applied to representative, circuit-breaker ratings, Table I is included.

Table I. Allowable Current Increase With Reduced Ambients

Ambient Temperature in Degrees Centigrade	Allowable Current in Amperes		
	2,000 Amperes Rated Current	1,200 Amperes Rated Current	800 Amperes Rated Current
40	2,000	1,200	800
30	2,320	1,390	930
20	2,580	1,550	1,030
10	2,740	1,640	1,090
5	2,780	1,660	1,110
0	2,810	1,700	1,130
−5	2,840	1,700	1,130

These data could serve very readily as a guide when special conditions are encountered, such as for sleet melting.



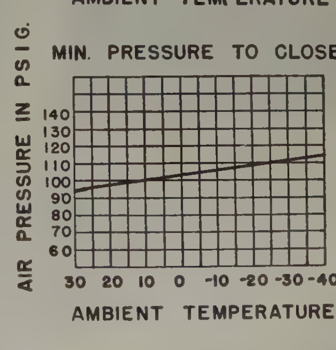


Figure 5. Operating performance data obtained on 34.5-kv outdoor oil circuit breaker during "cold room" tests in which the ambient temperature is measured in degrees centigrade

At this time, currents above the circuit-breaker name-plate rating may have to be used to raise the temperature of the line conductors to prevent sleet formation. Since the temperatures at this time are usually around freezing, the data would indicate that approximately 140 per cent of name-plate rating could be carried safely without subjecting the contacts to overheating.

Interrupting Performance. Two factors which are related to the interrupting performance are affected by low ambient temperatures, that is, oil flow and contact speed. Both are modified by changes in the viscosity of the oil.

Modern interrupters utilize turbulence and flow of the oil to help interrupt an arc so it is very important that the oil characteristics remain fairly constant over the temperature range normally encountered in service. With wide changes in viscosity it is to be expected that interrupting performance would be affected.

Operating Times. At low temperatures operating times will be affected by the changes in viscosity of not only the tank insulating oil but of the lubricants used at the bearing points of both circuit breaker and operating mechanism linkages. These changes retard the motion of the moving parts and the breaker operation will be slower with longer operating times. The effect naturally will vary with the ambient temperature.

This is illustrated by data taken during a "cold room" test on a standard 34.5-kv tank-type oil circuit breaker operated by an air mechanism. The breaker was located in a special test area where the ambient temperatures could be controlled. Then operating tests were made under no load conditions. Figure 5 shows the variations in operating speeds, closing times, and minimum pressures to close and latch in with ambient temperatures that varied from +30 to −40 degrees centigrade.

Each of these characteristics shows a definite indication of being affected by the lowering of the ambient temperature. Since these tests were made on a modern circuit breaker, it is believed that the results represent minimum variations. Older types of breakers with slower solenoid operators could be expected to show more marked variations in performance.

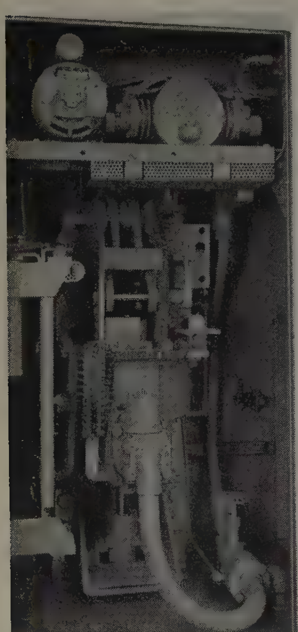


Figure 6 (left). Air operator for outdoor oil circuit breaker which uses protected calrod heater under compressor support and cartridge heater in air control valve for cold-weather operation and strip heater at back of housing to reduce condensation. Figure 7 (right). Tank heater installation showing power connections for frame-mounted circuit breakers

OPERATION AND MAINTENANCE

Successful operation of these circuit breakers is a requisite, naturally, regardless of the ambient temperatures that may exist. As reviewed in the previous section, low ambient temperatures have a direct effect on the mechanical operation of a breaker. This can mean longer operating times, slower speeds, unreliable operation, and possibly poor interrupting performance. The chief effects of low temperatures show up at two locations: the operating mechanism and the oil in the tanks.

The operating mechanism is affected by the changes in the lubricant and insulating oil. Both increase the loading on the mechanism and therefore slow it down. Closing may be unreliable where the closing force is not sufficient to overcome the added resistance of the thickened lubricant and tank-insulating oil. The back pressure on the trip latch may be so reduced by the added friction of the linkage bearings that tripping is unreliable. Trip linkage parts, which depend on light springs to reset them or to co-ordinate their relative motions, may fail to operate properly. The results will vary with the condition of the lubricant and the design of the mechanism. Generally speaking, the older mechanisms have less reserve built into them to take care of temperature variations. It is with these mechanisms that experience shows cases of actual trouble both on tripping and closing.

The widespread use of compressed-air operating mechanisms has introduced an additional problem. These mechanisms which are used only for closing do not require dry air for successful operation and, therefore, no special arrangements are made to remove moisture from the air. If freezing of this moisture occurs in certain parts of the control system, operating failures can result.

The change in tank insulating oil and the effect that it may have on circuit breaker operation and circuit interruption has been described previously.

The obvious method of preventing low ambient temperatures from affecting circuit-breaker performance would be to apply heat to the affected parts to raise their temperatures to a more normal level. This would seem to be a more practical answer than the building of special designs to operate satisfactorily at low ambients. The advantages of standard breakers would be retained with these special provisions used only where required and on few applications.

Since most of the affected parts are located in two general areas, this answer can be rather easily applied. The operating mechanism always has a sheet metal enclosure which makes it possible to treat it as a unit. The amount of heat added within the housing will vary with the temperatures involved and the heat loss through the walls of the enclosure.

This loss can be controlled by a low-loss insulation lining with a resulting decrease in the power required by the heater unit. In general, heating the interior of the housing will take care of all of the problems encountered. However, location of the heating unit at the more critical points will prove to be practical especially with air operators where it is necessary to prevent the freezing of any condensate in the immediate region of the air system valves and accessories. This provides safeguards where required and uses the minimum heater capacity. Figure 6 illustrates this approach where a total of 425 watts in two heater units will raise the temperature of specified areas above 32 degrees Fahrenheit with a −40 degrees Fahrenheit outside ambient.

The tank oil can be readily heated by either of two methods: immersion heaters extending through the wall of the oil tank, or heater units mounted on the outside of the tank bottom and enclosed to prevent heat losses directly to the air. When immersion heaters are used, they should have low sheath temperatures so that direct contact with the oil will not cause overheating and sludging. When these heaters are located in pockets so they can be removed without draining the oil, the same precautions should be observed because they then operate in air. Figure 7 shows a typical installation for a frame-mounted circuit breaker. Figure 8 is a view through the maintenance manhole of a floor-mounted breaker, showing in the background the two cylindrical housings for immersion-type heaters. Thermostatic control can be provided for any of these heater units so that their use is automatically determined by the ambient temperature.

Maintenance on oil circuit breakers operating under low-ambient-temperature conditions in general will follow accepted practices. However, to be sure that satisfactory operation will occur, cold-weather operating tests should be made. These should include travel-time charts so that both contact speed and timing can be checked. Operations under minimum closing and tripping conditions should be made.

If the performance is not satisfactory and within prescribed limits, the insulating oil should be checked for pour point and viscosity. If these characteristics are not equivalent to those of *10C* oil, the oil should be replaced. The last step, if the performance is still not acceptable, would be to add heater units in the mechanism housing and oil tanks.

CONCLUSIONS

THE CONSIDERATIONS that have been presented indicate that when operating outdoor oil circuit breakers under low ambient temperatures:

1. Air operating mechanisms require special consideration wherever the minimum ambient temperatures will fall below 32 degrees Fahrenheit. This means the use of heating units in the housing to prevent freezing of condensate at specified points of the control and air system.

2. Even modern outdoor oil circuit breakers require special consideration within the areas of Figure 1 where the average daily minimum temperatures for the coldest month are 20 degrees Fahrenheit and below. This is caused by the effect on lubrication and tank insulating oil.

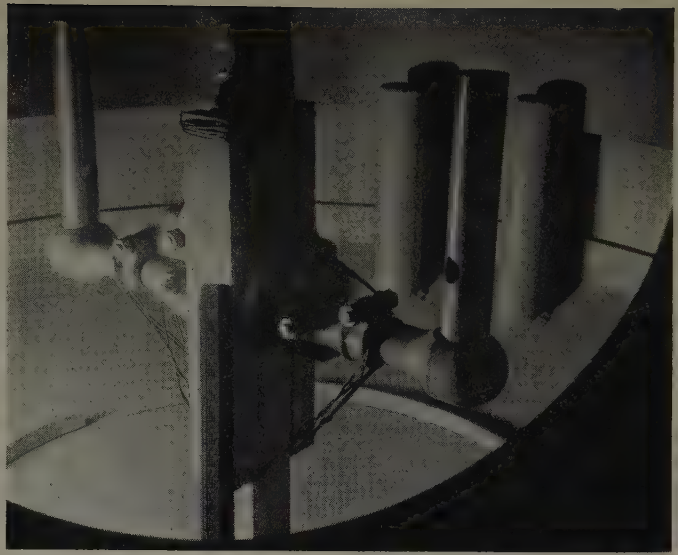


Figure 8. Housings attached to tank bottom for two tank heaters as used for floor-mounted circuit breakers

However, experience with standard circuit breakers in the areas just designated generally has been satisfactory, so it seems evident that there are other factors which influence the breaker performance under actual service conditions and make special provisions unnecessary. One of these could be that the minimum ambients are of short duration and therefore do not affect seriously the temperature of the main oil body which has considerable time lag. Another factor could be that a breaker which is carrying load is transferring heat to the oil which therefore does not reflect the actual ambient temperature.

This being the case, it seems possible to conclude that special provisions are not required where the average daily minimum temperatures for the coldest month are above 0 degrees Fahrenheit. In other words, the factors just mentioned permit operation at temperatures 20 degrees Fahrenheit lower. Following this practice would mean also that definite provisions for tank heaters and additional housing heaters would be required for areas where the average daily minimum temperatures for the coldest month are below 0 degrees Fahrenheit. As a matter of interest, this practice is being followed by one of the large Canadian circuit breaker manufacturers.

However, the subject seems to require further study and consideration because it is quite evident that if the same performance characteristics are to be maintained at low ambients, the factors mentioned previously cannot always be relied upon to furnish the protection that is required.

While the lower ambients in general seem to present problems that require special consideration and extra equipment, the increased current-carrying capacity for sleet melting is a decided advantage and many existing circuit breakers can be utilized for this service.

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Sliding Contacts—A Review of the Literature

FRANK SPAYTH STANTON EAST

The literature on sliding contacts is reviewed with emphasis placed on basic phenomena. The subject is covered under the headings of contact wear, contact configuration, contact resistance, generated noise, contact force, and contact surfaces. Each of these factors is evaluated in terms of its effect on sliding contacts. Recommendations for improving sliding contacts also are included.

THE CONTINUED USE of rotating devices incorporating electric apparatus has resulted in sliding contacts playing an increasingly important role in our daily lives. Problems arise which require low noise level, high current, low resistance, low wear, or ramifications of these variables. In general, the method of attack has been trial and error development, backed by engineering experience. Correlation of fundamental theory with practical experience is largely lacking as might be expected because separation of independent and dependent variables is a difficult task.

BASIC CONSIDERATIONS[1–9]

CONTRARY TO OUTWARD APPEARANCES, the actual physical and electric contact between two conductors has been established by R. Holm[1] to be a small fraction of the apparent area. That is, the actual contact is made where several microscopic protuberances of the two surfaces mate. Acting under the bearing load, the protuberances will flatten and increase the total contact area; however, some of the flattened area may be contaminated with monomolecular films. These spots are called "quasi-metal" spots by R. Holm, and the tunnel effect is responsible for conduction. Still other parts of the flattened area may be covered with insulating film where no conduction takes place, as noted in Figure 1. When referring to contact area, the terms "apparent" and "actual" will be applied. Since the actual contact area is not always known, the term "contact pressure" does not normally apply, hence "contact force" will be used.

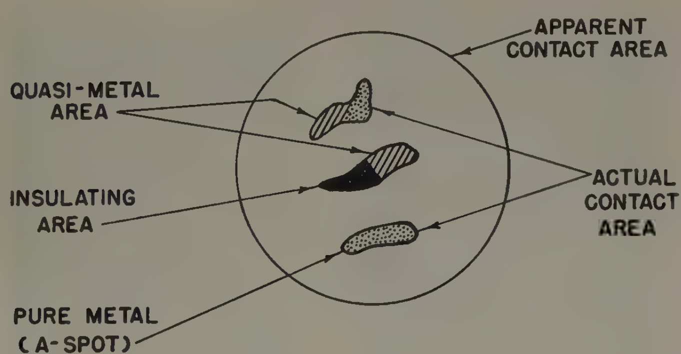

Figure 1. Cross section between two contacts showing the different contact areas

When dealing with metals on the macroscopic level, one often ignores the processes that occur on the microscopic or submicroscopic level. The processes that are of greatest concern here are the ones that contribute to the strength of the metal on a microscopic level. Here it is found that the metal is strongest in the crystal and weakest in the grain boundaries. Figure 2 illustrates the case of a metal surface subjected to theoretical force. As noted, the metal will shear or break off at the weakest point upon which the forces are acting.

CONTACT WEAR

Mechanical.[10–17] Mechanical wear of sliding contacts is caused by the work of friction.

The nature of mechanical wear is of three types:

1. Abraded powder or atomic wear.
2. Granular wear.
3. Exorbitant wear.

Which of these three types of abrasion is occurring can be identified by the amount of wear that occurs and the nature of the surfaces. The equation for abrasion is[1]

$$A_o = \beta \frac{Ps}{H} \tag{1}$$

where

A_o = Weight loss, or wear
P = Bearing load
s = Distance traveled
H = Hardness of the material
β = Parameter

The quantity β is treated as a constant, but varies widely with material, humidity, surface films, and so forth. The physical meaning of β is the number of abraded atoms per atomic encounter. β varies for different types of wear, as follows:

Atomic wear occurs when $\beta < 1$.
Granular wear occurs when $\beta > 1$.
Exorbitant wear occurs when $\beta >>> 1$.

For $\beta < 1$, a lubricant of some type is present, and acts hydrodynamically, or as a boundary lubricant. For $\beta > 1$,

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usually dissimilar clean metals are being used. For $\beta >>> 1$, clean similar metal contact is being made.

Exorbitant wear also will occur when:

1. The rotating member is not true and vibration ensues.
2. The brushes are not aligned properly.
3. Foreign particles such as sand or dust are in the interface or on the surfaces.

Hydrodynamic lubrication is a type of lubrication well known in industry, but is of little value in sliding contacts as the film is usually too thick to conduct electrically. Boundary lubrication acts similarly to hydrodynamic lubrication. The lubricant is an epilamen, or monomolecular layer, which adheres to the surfaces in question by strong Van der Waals forces. Removal of these films is very difficult by chemical processes, and theoretically impossible by the force of friction. Lubricant molecules which are able to form epilamen are usually long hydrocarbon chains, with an active group at one end. Experimental results also show that water, which has an electric dipole, does act as an epilamen.[1]

One case in which water may act as a lubricant is in humid atmospheres. Several observers have measured the minimum water content at which lubrication starts for carbon and copper.[15,18] By correlating their results to standard conditions, one finds a remarkable agreement at 3.3×10^{-6} gram per cubic centimeter (20 degrees centigrade) as the minimum. Graphite brushes provide their own lubrication in the form of graphite flakes. An instructive experiment by Heaton, Bristow, Wittingham, and Hughes[19] points to the use of tin as an epilamen. They measured the coefficient of friction of a steel ball on a copper plate which had been lubricated with tin, and found the coefficient to be in the same class as a plate with hydrocarbon epilamen.

When clean similar metals are in contact, abrasion is severe. A plausible explanation is that the metal-to-metal contact, or interface, is held together by cohesive forces, which are of the same magnitude as the forces which hold the metal itself together (see Figure 2). Slip planes occur in layers of minimum shear, and, with slight imperfections of the layers under the interface, these layers may become shear lines. Assuming such a mechanism of friction, dissimilar metals should wear less, which is the case. The forces of adhesion in the interface are presumably less than the cohesive forces in the metals.

With regard to carbon, evidence points to oxygen of the air diffusing into layers below the interface. With the high local heat of friction as a catalyst, combination with the graphite binder occurs. The binder loses its control after chemical combination, and releases granules to the sliding motion. An oxygen-free atmosphere should prevent the possibility of such a chemical combination. Experiments by Baker[18] on carbon in hydrogen and hydrogen-mercury vapor atmospheres show extremely small abrasion rates, thus confirming this point.

Electrical Wear[1,10–14,16,17]

1. *Nonarcing current.*[1] No satisfactory equation governing the amount of electrical wear on sliding contacts from nonarcing currents is available. Investigators are not in agreement as to whether or not friction and the work of friction is dependent on current.

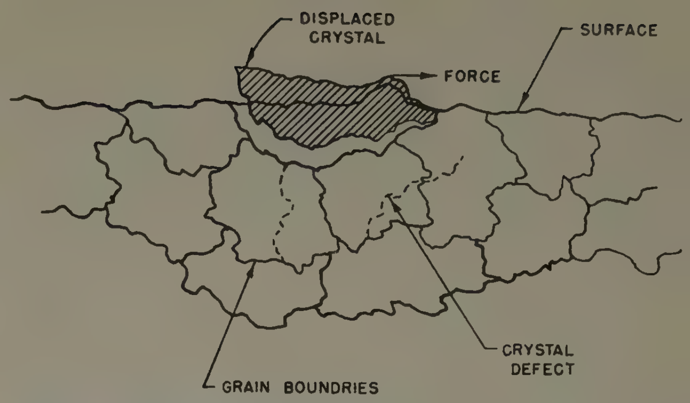

Figure 2. Effect of a transverse force on a normal metallic surface

Electrical wear does occur, however, and is proportional to the parameters of the electric circuit. Also it is influenced materially by the mechanical characteristics of the system. The rate of electrical wear is dependent on:

1. Magnitude of current.
2. Surrounding medium.
3. Bearing load.
4. Velocity of travel.

Although impractical, the equation of wear is theoretically:

$$A_1 = a_1 S + a_2 I^{\alpha_1} + a_3 P^{\alpha_2} + a_4 v^{\alpha_3} \qquad (2)$$

In equation 2

a_1, a_2, a_3, a_4 = Constants which depend primarily on the surrounding medium and the surfaces
S = Distance traveled
P = Bearing load
I = Current
v = Velocity of travel
$\alpha_1, \alpha_2, \alpha_3$ = Powers of the variable

Hessler graphed the effect of current on wear using carbon brushes and copper rings, see Figure 3. Graphs *A* and *B*

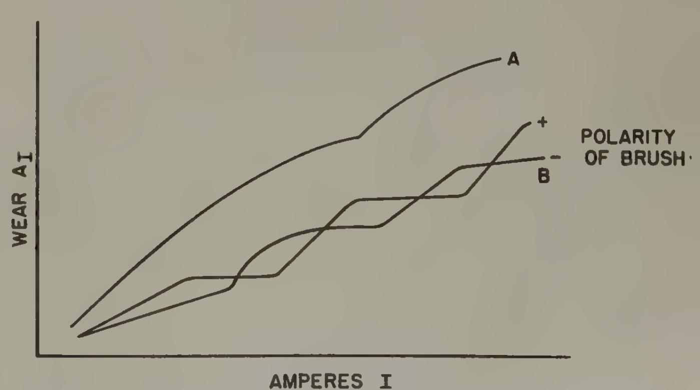

Figure 3. Wear of a carbon brush on a copper ring. A and B represent two grades of carbon. Differences in wear rate with polarity indicated for brush B

represent different grades of brush carbon. Apparently α_1 in equation 2 is approximately one.

Soper has supplied data which show an intimate relationship between current density and frictional torque. The torque varies with current density, but the changes are different for a positive or negative brush. Soper's explanation is that the increase in current increases the slipping or actual contact area, and that this change of area accounts for the change in frictional torque.

2. *Arcing current.*[1,20] Evaporation from the cathode caused by an arc is the same as evaporation from make- and break-type contacts. A very important point to consider about the arc on sliding contacts is that roughening of the interface occurs which increases the mechanical wear considerably. No complete analysis of this problem has been made to date; however, when working with arcing currents, utmost care should be taken to secure proper alignment of the surfaces and freedom from vibration and bounce.

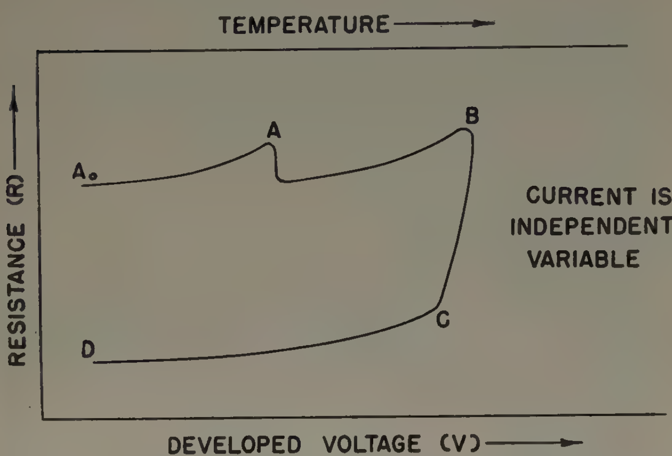

Figure 4. Voltage V_s–resistance characteristic for clean contacts

CONTACT CONFIGURATION

Configuration recommendations depend on the application. For instance, cylindrical contacts are recommended for use in a potentiometer and connected with the axis of the cylinder parallel to the axis of the resistance wires lying on the surface of the ring. This configuration insures contact with just one resistance wire-turn at one time, and is a requisite for linearity and accurate positioning.

In general, flat perfectly mated surfaces are preferred to insure good sliding contact. Carbon brushes for electric motors and generators have been redesigned many times. Brush faces are made with

1. Axial slots.
2. Circumferential slots.
3. Diagonal slots.
4. Holes perpendicular to the face.
5. Prow-shaped brushes.
6. Combinations of the foregoing.

The greatest effect is to decrease the contact resistance, especially with brushes of types 1 and 5. Generally, friction is increased when using the various brush face designs.

CONTACT RESISTANCE[1, 16, 13, 14, 21–26]

The contact resistance of the interface is a dynamic condition which results from the mechanism of physical contact described in the introduction. Initially, if one assumes a set of contacts to be stationary, the only possible paths of conduction are through the areas where actual contact occurs. One can regard all these spots as resistors connected in parallel. The important resistance value is the constriction resistance of the *A*-spots, since this will be close to the over-all value. As I increases from zero, R and E both increase (A_0-A, Figure 4), R becomes larger because of the greater constriction and dependence of resistivity on temperature (temperature here is the supertemperature at the *A*-spot).

When I reaches the softening range of the *A*-spot (A, Figure 4), the contact area increases under the steady contact load. At this point, the resistance will decrease immediately, due to the decrease in current constriction. After final softening, R and V again will increase as before ($A-B$, Figure 4), until it reaches the melting point of the *A*-spot (B, Figure 4). At this point the voltage will not rise again, no matter what value I assumes, because more current will lead only to more melting and decreasing resistance. This melting of the interface is an irreversible deformation. Upon decreasing the current to zero (D, Figure 4), the R and V values will be lower at any value of I. This is the well known R-V characteristic. R-V curves for tarnished *A*-spots are somewhat similar (see Figure 4); however, the mechanism of conduction differs.

Conduction from A to B to C is by the tunnel effect in thin films, and is attributed to an increase in the number of mobile electrons. During this period I increases very slowly. At point C (location of C depends on the film thickness), the developed voltage reaches the puncturing voltage of the film and a hole occurs, which is immediately filled with molten metal. At this point, R decreases suddenly. The developed voltage then reverts back to the melting voltage, while the hole of molten metal enlarges until a solid connection results.

Assume now that the stationary sliding contacts have reached an equilibrium voltage. As soon as the contacts begin to slide, *A*-spots and quasi-metal spots will be formed and the process of reaching puncturing and equilibrium voltages will begin anew. See Figure 6.

The location, number, size, and tarnish of the real contact areas will change steadily, and the voltage record (see Figure 6) will be a complex average of all the individual contributions. The average value of the fluctuations is roughly that of the melting voltage of the material used (with dissimilar metals, the lowest melting voltage). This mechanism of conduction will describe adequately contact noise, as will be seen later.

Recommendations for low resistance and low-resistance fluctuations in sliding contacts are

1. The use of tarnish-resistant metals. Since the voltage developed due to melting is lower than the magnitude

of voltage required to puncture a tarnish film, the amount and magnitude of these fluctuations varies with the materials' film characteristics.

2. Operation at lowest practical linear velocity. Time is an important factor in establishing conduction.

3. Operation at maximum practical bearing load. The recommendation of high bearing load here contradicts the recommendation for low mechanical wear. Use of a material like silver-graphite is an answer to the problem. High bearing loads are recommended (for the hardness of silver). The carbon skeleton assumes the load however, while the silver interface assumes the conduction, and both low wear and high conductivity result.

Carbon and carbon-base materials used as brush or ring contacts are amorphous carbon, electrographitic carbon, natural graphite, and silver, rhodium, or copper graphite.

Materials used for low resistive losses include silver, copper, copper-silver alloys, precious metal alloys of platinum, palladium, and rhodium, and complex alloys of silver, copper, gold, platinum, zinc, and palladium.

GENERATED NOISE[16, 22–28]

GENERATED NOISE, as applied to sliding contacts, is the completely random voltage fluctuation whose source is the interface, and whose magnitude depends on one of several mechanisms which can exist in the interface.

Thermoelectric Noise. The use of dissimilar metal is common in sliding contacts. Any two dissimilar metals in contact, having different thermoelectric properties, will develop a thermoelectric voltage at the junction or interface which is approximately proportional to the absolute temperature of the junction. Because the work of friction heats the intimate contact areas (*A*-spots) to temperatures approaching the melting point, a considerable voltage may be generated, which will be completely random and of the nature described previously. The average magnitude of these electromotive forces easily could be 10 millivolts.

Recommendations for minimizing thermoelectric noise are to

1. Reduce friction to a minimum value, thereby reducing the super temperature in the region of the *A*-spots and the ambient temperature of the contacts. Lubrication is advised.
2. Use materials that have nearly the same thermoelectric properties.
3. Use similar materials, if lubrication minimizes the frictional heat, and wear is not a problem.
4. Utilize low load current where possible.
5. Have external cooling, if necessary (air or liquid).

Electrostatic Noise. Random voltage fluctuations may occur by rubbing contacts that have an insulating film on one or both faces. Development of voltage noise occurs after the insulating film has picked up electrostatic charges. The distribution of charges will be nonuniform, as will be the image charges which are set up in the nearby conductors (*A*-spots). It is the nonuniform distribution and motion of the charges on the conductors that constitute electrostatic noise.

The use of tarnish-free contacts is recommended to minimize electrostatic noise.

Thermal Noise. In all parts of the electric circuit thermal noise exists. Briefly, its reduction is attained by making the frequency bandwidth as small as possible, along with low temperatures and low resistances. As many others[1] have treated this subject very well, it will not be discussed here in detail.

Contact Noise. According to Richardson,[27] contact noise

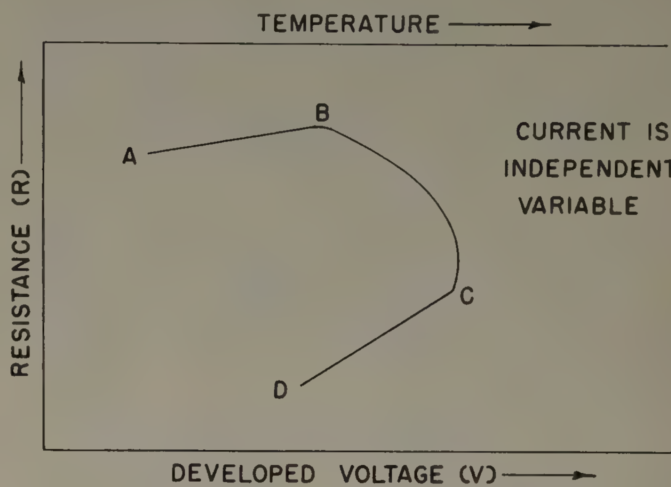

Figure 5. Voltage V_s–resistance characteristic for tarnished contacts

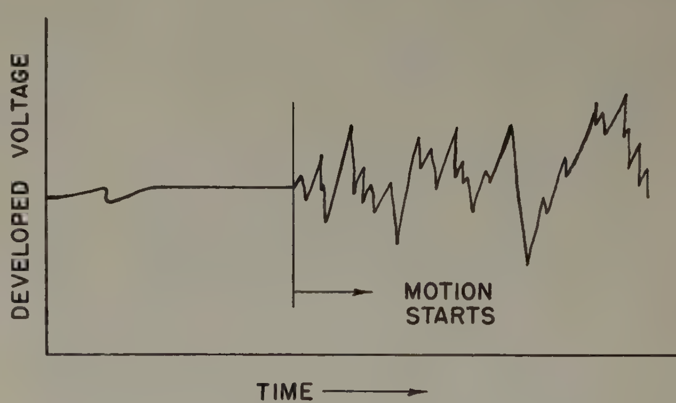

Figure 6. Effect of sliding on voltage across contacts

differs from thermal noise by the fact that its rms value in any frequency range is proportional to the magnitude of the averaged applied current. The origin of contact (sometimes current) noise is believed by many to be the spontaneous resistance fluctuations of the element in question (*A*-spots). In the light of many investigations, it seems reasonable to believe this to be true. Thus an adequate description of contact noise has been presented under contact resistance. Only when the signals being conducted are of the order 10–50 microvolts, is this resistance fluctuation called contact or current noise.

To overcome this effect, the following steps should be taken:

1. Freedom from films (controlled atmosphere).
2. Low frictional heat. Transfer of heat takes place over a large area and in depth.
3. A large total real conducting area (freedom from large constriction resistances).
4. Little change in the total conducting area.
5. Small bearing load.

Total Noise. An extensive search for low noise contacts has been made by B. M. Horton. The signals he was concerned with were on the order of 10 microvolts or less. Results of a few combinations are shown in Table I. Of the materials selected for his tests, he found amalgamated copper and mercury (liquid) to be the best combination, with an approximate noise level of 1 microvolt.

Table I

Ring	Brush	Generated Noise in Microvolts	Normal Force in Grams
Silver	G	0.3	50
	SG 1	0.3	50
	SG 2	2.5	50
Rhodium	G	0.8	30
	SG 1	0.5	60
	Rh-G	0.4	50
Gold	G	0.6	40
Cu (oxidized)	G	11 to 1.0	50
Rhodium (coated with AgS)	SG 1	14.0	60
Electrographic Carbon	G	1.0 to 9.0	900

G = Natural graphite.
SG 1 = Silver graphite, fine texture, low silver.
SG 2 = Silver graphite, coarse texture, high silver.
Rh-G = Rhodium graphite (73-per-cent rhodium).
11 to 1.0 = This means the level of noise decreased from 11.0 to 1.0 microvolts as time increased.

Measurements were made in the frequency range 0.5 to 200 cycles.

Recommendations for minimizing total contact noise are

1. Low friction.
2. Low speeds. Noise increases with speed, since time is an important factor in establishing conduction.
3. Use of any independent sets of contacts in parallel (insures conduction and smooths the fluctuation).
4. Choice of normal force or bearing load (increasing or decreasing the load increases or decreases the noise depending on the condition of the rubbing surfaces).
5. Tarnish-free contact surfaces.

CONTACT FORCE[1, 3, 21, 23, 24]

Values of the contact force used are mainly dependent on the yield strength of the softer material and consequent mechanical wear, and the amount and kind of resistances which interfere with electric conduction.

The application of bearing load to contacts causes the initial contact (microscopic protuberances) to deform inelastically. This deformation will continue, and other smaller protuberances will meet. The total microscopic area will increase until the bearing load can be supported without further deformation. This value is theoretically the hardness of the material.

For minimum contact mechanical wear, the bearing load should be small (refer to section on mechanical wear). On the other hand, good conduction calls for high bearing loads. High bearing loads decrease the constriction resistances, and break up and wear brittle films to allow metal contact. Tarnish-free contact materials are used generally with bearing loads as low as 20 to 50 grams depending on the application. (Carbon-family contacts are used with bearing loads as high as 5 pounds per square inch of apparent brush area).

As stated in the section on contact noise, the generated noise will increase or decrease inversely with respect to the normal force. More specifically, the effect of increasing contact load is to decrease noise, unless a change has been brought about which greatly increases the work of friction (deformation changing from mainly elastic to chiefly plastic, or by the breakup of films which acted previously as a lubricant). Table II shows good agreement with theory.

Table II

Microvolts Generated Noise	Grams Bearing Load
1.16	10
1.14	20
1.16	30
1.08	50
0.93	100
0.72	200

Rhodium-graphite brush on rhodium-speed 116 rpm[24]

CONTACT SURFACES [1, 5, 21]

The interface has been mentioned previously. Its importance warrants special consideration. The total minimum thickness of the interface is approximately 70 Angstrom units and becomes increased by tarnish films. The layers of a tarnish-free polished interface are[5]

1. Beilby layer* of one contact.
2. The effective contact spacing.
3. Beilby layer of the other contact.

The layers of a tarnished interface are

1. Beilby layer of one contact.
2. Tarnish layer of the contact in item 1.
3. Effective contact spacing.
4. Tarnish layer of the other contact.
5. Beilby layer of the other contact.

The word tarnish, as used here, means the presence of atoms or molecules which are bound to the surface, but are not atoms of the parent surface.

More important than the layers, are the voltages that are developed in the interface while passing current. Typical examples of voltage drops in a brush on a ring are illustrated as follows:

V_1 = In the Beilby layer (constriction resistance).

* Beilby layers occur from the process of polishing. Studies of X-ray diffraction patterns show that this layer is an entirely amorphous arrangement similar to atoms in a liquid. The layer depth depends on the amount of polishing, but is usually 30 Angstrom units. This layer is harder and more resistant to mechanical wear than the polycrystalline body. The main agency for this formation appears to be the momentary liquifaction due to the heat of friction. Cold working also plays an important role. The frictional stresses which produce this disintegration cause less orderly arrangements of higher potential energy, that is, the work of friction produces stored energy in the surface as well as evolving heat. The stored energy is usually in the form of "strains," which explain the existance of a few "emission" points in developed surfaces.

V_2 = Brush to brush film (work function).
V_3 = In the film (tunnel effect).
V_4 = Film to gas (work function).
V_5 = In the gas (roughly Ohms Law).
V_6 = Gas to ring film (work function).
V_7 = In the ring film (tunnel effect).
V_8 = Ring film to ring (work function).
V_9 = Beilby layer of ring (constriction resistance).

The effective contact spacing is described by Soper.[21] This so-called spacing is measured by the field strength which exists at points where actual contact is being made. This field varies, and through judicious use of formulas, a value of distance can be ascertained. Smallest spacing is about 10^{-9} centimeter and is considered to be the spacing that would exist if perfectly smooth parallel surfaces were used.

The sum of V_1 through V_9 (some may be zero) constitutes the "contact drop," or the voltage developed by the interface. If, in the case of a carbon brush and copper ring, the brush polarity is positive, then a certain voltage drop occurs from the sum of the V's. When the brush is negative, one might expect a different voltage drop which can be seen experimentally. The reason is that the work function voltages (V_2, V_4, V_6, and V_8) would assume different values, depending on the current direction.

SUMMARY[2, 4, 5]

There is no doubt as to the complexity of the selection of materials for sliding contacts. When selecting a material, one usually must compromise on the characteristics that are most desirable. However, general rules that should be followed are

1. Use a lubricant (liquid or solid).
2. Utilize materials that will not react with the lubricant or atmosphere.
3. Use similar materials with lubricant for low noise and high wear.
4. Use dissimilar materials with lubricant for high noise and low wear.
5. Use as low a contact force as possible for low wear.
6. Use as high a contact force as possible for low resistance or noise.
7. Use the lowest possible surface speed.
8. Use many independent contacts in parallel to decrease noise.
9. Utilize tarnish-free surfaces.

There is no cure-all material that will cover all these nine points. However, with a careful evaluation of what it is desired to achieve, a sliding contact material and lubricant may be selected that normally will suit the application.

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Basic Concepts in Circuit Analysis

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IT HAS BEEN the authors' observation that a lack of agreement exists regarding the definition of such terms as "potential difference," "electromotance (electromotive force)," "voltage," and the meanings of laws involving these terms. This article attempts to provide distinguishing definitions, suitable for near zone analysis, of three circuit variables considered essential to the proper analysis of electric circuits, namely, potential difference, electromotance, and "*Ri* product"; to emphasize the importance of the $-\partial \mathbf{A}/\partial t$ component of the electric field in describing transformer action; and to present two legitimate but different forms of Kirchhoff's second law.

It is important to realize that a potential function exists for the electric intensity $\mathbf{E}$ in a (simply connected) region if and only if the closed line integral of the intensity is zero for every possible closed path. Such a field is conservative; that is, the net work required to traverse a closed path is zero. Since currents flow in closed paths it may be expected that energy cannot be picked up continuously by a current from such a field. Thus electrical engineers are necessarily concerned with nonconservative fields, and in such fields potential concepts are not applicable directly.

However, one may find a component of the total intensity, the *electrostatic component* $\mathbf{E}_s$, which is conservative in the region under consideration, and which is related to the magnitudes and positions of all charges by

$$\mathbf{E}_s = \frac{1}{4\pi\epsilon_0}\int \frac{\rho \mathbf{r} d\tau}{r^3} \quad (1)$$

In the general case the electrostatic component will vary with time. The difference between the total electric intensity $\mathbf{E}$ and the electrostatic component $\mathbf{E}_s$ is defined as the electromotive component $\mathbf{E}_m$. $\mathbf{E}_m$ is by nature nonconservative and hence can transfer energy continuously by means of a current.

There are many physical processes which give rise to an $\mathbf{E}_m$, but the electrical engineer is most concerned with that found in inductors and transformers. Briefly, whenever the currents in electric apparatus change with time, an induced $\mathbf{E}_m$ is produced which is given in terms of rates of change of currents and their positions by an equation similar to equation 1:

$$\text{Induced } \mathbf{E}_m = -\frac{\mu_0}{4\pi}\int \frac{\dot{\mathbf{J}} d\tau}{r} \quad (2)$$

In terms of the vector potential of the currents it may be shown that $\mathbf{E}_m = -\partial \mathbf{A}/\partial t$. The description of induction is here introduced in terms of a fundamental nonconservative component of the total electric intensity rather than by Faraday's law in terms of magnetic flux. This viewpoint allows one to see where the forces causing current to flow act on a circuit and how the electrostatic component $\mathbf{E}_s$ is adjusted by redistribution of charge to balance the electromotive component $\mathbf{E}_m$ to satisfy Ohm's law in conductors.

The three essential circuit variables are defined as:

$$\text{Potential decrease from } a \text{ to } b = v_{ab} = \int_a^b \mathbf{E}_s \cdot d\mathbf{l} \quad (3)$$

$$\text{Electromotance from } a \text{ to } b = e_{ab} = \int_a^b \mathbf{E}_m \cdot d\mathbf{l} \quad (4)$$

$$\text{Ri product from } a \text{ to } b = (\text{Ri})_{ab} = \int_a^b \mathbf{E} \cdot d\mathbf{l} \quad (5)$$

All three quantities are measured in volts. v_{ab} is independent of the path of integration, but both e_{ab} and $(Ri)_{ab}$ require knowledge of the path for their evaluation. The relation between the three is easily shown to be $v_{ba} = e_{ab} - (Ri)_{ab}$. The avoidance of the terms increase, decrease, rise, and drop in the general definitions of the electromotance and the *Ri* product is necessary because such terms have meaning only in connection with potential, and the line integrals of $\mathbf{E}_m$ and $\mathbf{E}$ cannot be described by potential functions.

The fact that the value of the potential difference is equal to the difference of the values of the electromotance and the *Ri* product does not, of course, mean that the last two are themselves potential differences, but there seems to be a powerful, if illogical, tendency to feel that it does mean just that. This confusion is heightened by the fact that devices with localized electromotances, such as batteries and lumped inductors, can be replaced as far as the terminal potential is concerned by a potential rise e_{ab} in series with a potential drop $(Ri)_{ab}$, the so-called *Ri* drop.

It is important to realize that in such devices the potential difference, and consequently the electrostatic component, are the only quantities available to do work on the external circuit. However, the nonconservative electromotive component must exist in order to set up and maintain against current flow the terminal potential.

Both forms of Kirchhoff's second law are consequences of the conservative nature of the electrostatic component. The potential difference form states the conservative nature of $\mathbf{E}_s$ in circuit terms; $\Sigma v = 0$. This form is essential in modern network analysis involving lumped elements.

The electromotance form is found by integrating equations 3, 4, and 5 around a closed path and using the relation $\mathbf{E}_m = \mathbf{E} - \mathbf{E}_s$. There results in circuit form $\Sigma e = \Sigma Ri$. This form is required in circuits everywhere linked by magnetic flux so that the electromotance and the potential difference of each branch cannot readily be evaluated. This form shows that in the general case the potential difference is not necessarily the measure of the energy transfer in a circuit.

Digest of paper 53-268, "Basic Concepts in the Analysis of Stationary Electric Circuits," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Multitransformer Welding Presses

JACK OGDEN

After presenting several distinct advantages of presswelding in high-production applications, some equipment requirements and techniques applicable to multitransformer presswelding are discussed.

USERS OF resistance welding equipment are finding "presswelding" to be ideally suited to many of their high-production applications. In its general concept, presswelding may be likened to present-day stamping press practice; however, instead of forming or trimming, the weld-press produces from 16 to 160 spot welds practically simultaneously on a given assembly. The welding press also differs from the usual stamping press in that the ram or movable platen is generally located in the lower part of the machine. This arrangement facilitates the location of the welding units and usually favors loading of the parts to be welded. Figure 1 shows three typical press types. The 4-post machine is used for large assemblies, the 2-post or open press for smaller operations.

The press platens are operated by motor-driven linkage systems or fluid pressure cylinders. On large presses, the platen weight is usually counterbalanced with an air cylinder system.

The welding electrode units, see Figure 2, correspond to the dies used in a stamping press; the upper or stationary electrode usually consists of a framework supporting the electrode pressure units, the welding transformers, the cooling and pressure medium manifolds. The lower electrode assembly supports the backup electrodes and part locators.

In some more complicated units, the electrode pressure cylinders and welding transformers may be located both in the upper and lower electrode assemblies. To utilize fully the advantages of the press system, the electrode assemblies should be designed to permit easy removal and replacement of the entire electrode unit. This makes it practical to utilize a given press line for several different operations.

In early forms of the presswelder, comparatively large transformers were attached to the crown or base of the press and connected to the electrodes by long secondary cables. The advent of the small package transformer permitted locating the transformers on the electrode assembly, thus greatly facilitating electrode changes and reducing primary current demands.

Presswelding has several distinct advantages in high-production applications. Some major advantages of this system are that it

1. Permits accurate, uniform locations of spot welds.
2. Allows welding of a large number of assemblies on one high-production fixture rather than on a number of like lower-production fixtures thus eliminating the particularly vexing problem of fixture co-ordination.
3. Permits the use of one or a group of presses for a number of different welding operations in the same manner that a stamping press can be used for producing different parts by changing dies.
4. Increases electrode life and virtually eliminates production shutdowns for electrode dressing as individual electrodes produce only one or two welds per assembly.
5. Lends itself exceedingly well to automatic part-handling equipment, particularly in progressive operation setups.

The successful employment of presswelding to improve quality and reduce production cost requires particular emphasis on the following items:

1. Loading and unloading of parts and assemblies.
2. Development of simple accurate part locators.
3. Design and maintenance of equipment to reduce production "down time." This becomes extremely important on progressive operation installations where four or more presses may be synchronized in line.
4. Proper maintenance of electrode tips and backups.

SECONDARY VOLTAGE CONTROL METHODS

1. The use of tap-changing welding transformers permits the maximum voltage flexibility where accessibility and space considerations permit their installation.
2. Some systems employ one large autotransformer per phase with multiple switching devices feeding groups of two or more welding transformers, see Figure 3. Economy and space considerations make it impractical to adjust welding transformer voltages individually by this method. However, fixed-ratio welding transformers may be more compact in design for the same secondary current outputs.
3. Although not as widely used as methods 1 and 2, the variation of secondary output by means of phase-shift heat control has many interesting possibilities. It provides stepless heat control with minimum space requirements and compares quite favorably costwise with the other methods if transformers are grouped as in the autotransformer system.

WELDING TRANSFORMERS

THIS SUBJECT has been thoroughly covered by D. L. Knight,[1] but it probably will not be amiss to emphasize

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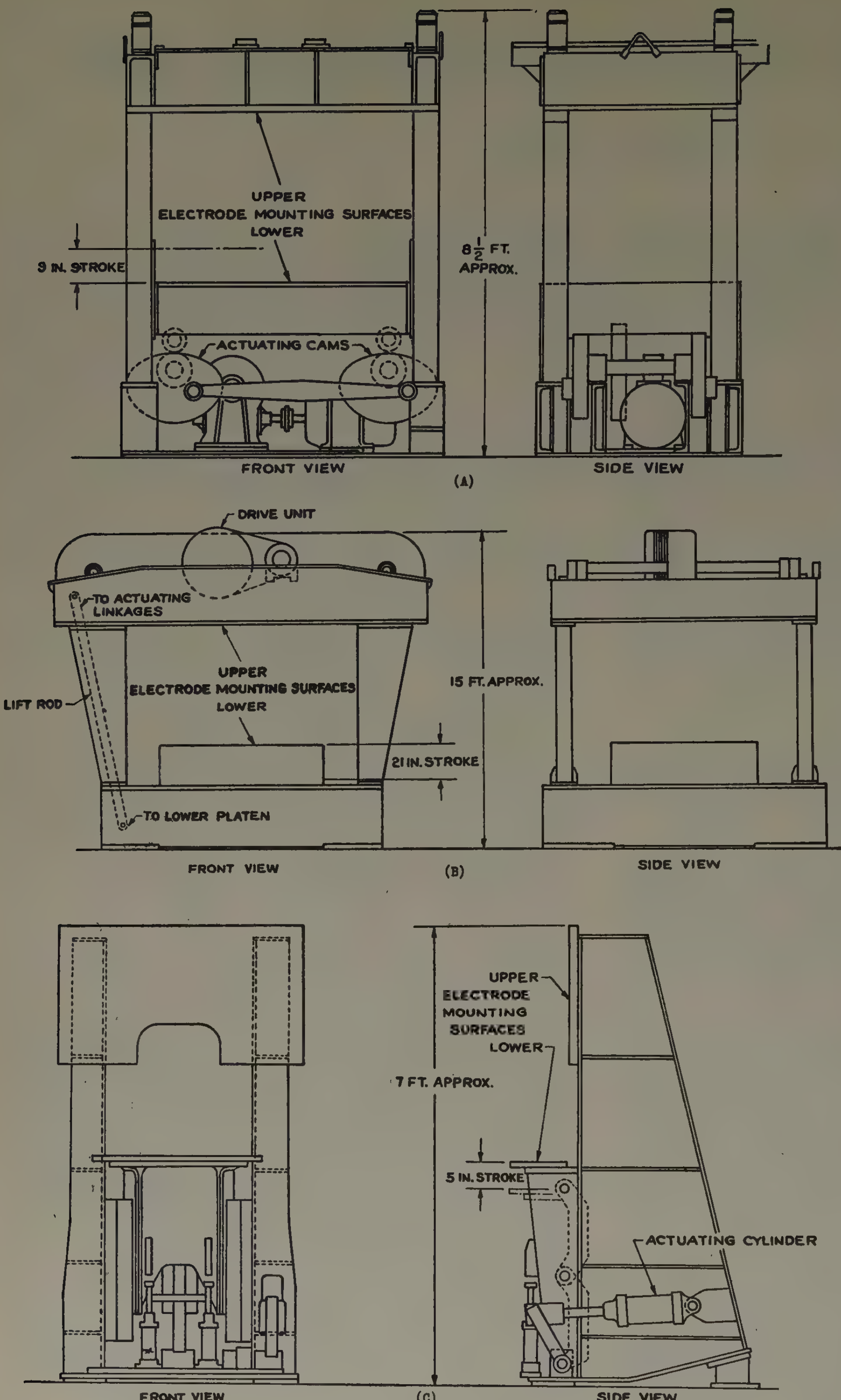


Figure 1 (left). Typical press types: A. Four post, cam type; B. Four post, crank type; C. Two post, hydraulic type

that the welding transformer should be as compact as possible and extremely rugged as it usually is mounted in exposed locations. It probably will be subject to more severe water and oil exposure than the average transformer. Particular attention should be given to secondary terminal bracing and location. Mounting must be convenient and flexible. Polarity indication should be obvious in view of its importance in this type of welding. In practice, most transformers of this type fail either for mechanical reasons or due to moisture breakdown of the insulation.

SECONDARY CIRCUITS

1. *Series Method.* From a machine-design standpoint, this method, see Figure 4, is an ideal arrangement and consequently is used very widely. Series welding has been a large factor in the widespread adoption of presswelding. The number of secondary circuits required for direct welding is reduced by half due to the fact that feed and return paths are both on the same side of the part. The secondary impedance can be kept to a minimum and consequently primary current requirements may be reduced. Inherently this circuit tends to produce very little indentation on the backup side of the part and rather deep indentation on the 'hot'' electrode side due to the tendency of the stock adjacent to the hot electrode to shunt part of the current from the weld. The metal on this side is usually less than 0.050 inch thick.

2. *Direct Method.* As shown in Figure 4, this differs from the usual spot-welding secondary circuit only in the fact that there is no permanent connection between the transformer and the backup electrode. The use of a contact pad or wiping contact simplifies the mechanical machine design and improves the loading conditions. The direct-welding circuit is frequently used for stock thicknesses of over 0.050 inch where the welds are close to the edge of the assembly.

3. *Opposed Secondary Method.* Again referring to Figure 4, it can be seen that this method combines the series- and direct-welding principles. Although it requires the same number of secondary circuits as used in direct welding, it does greatly reduce the impedance when producing welds near the center of a large assembly. This process does not have the stock thickness limitations characteristic of series welding. When the same contour electrodes are used on both sides of the assembly, the leakage of current

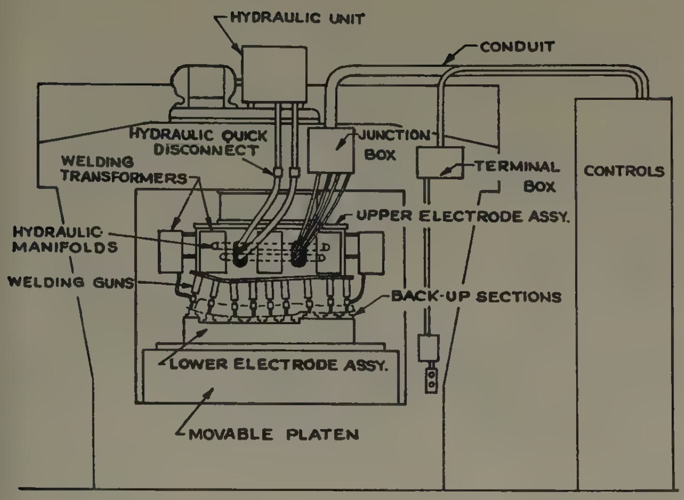


Figure 2. Welding press showing electrode installation

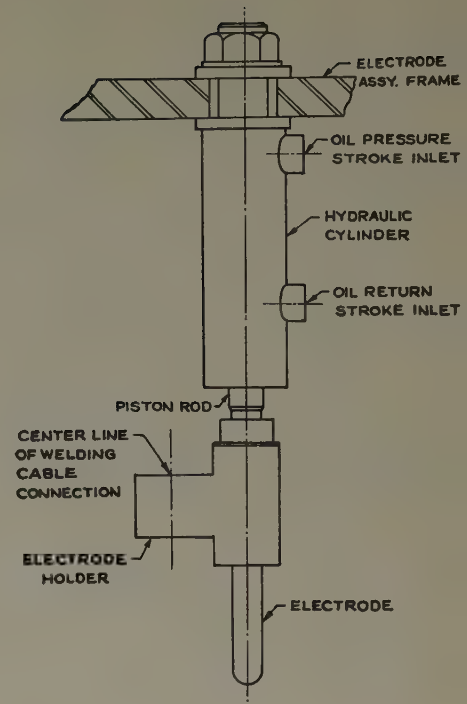


Figure 5. Typical welding gun

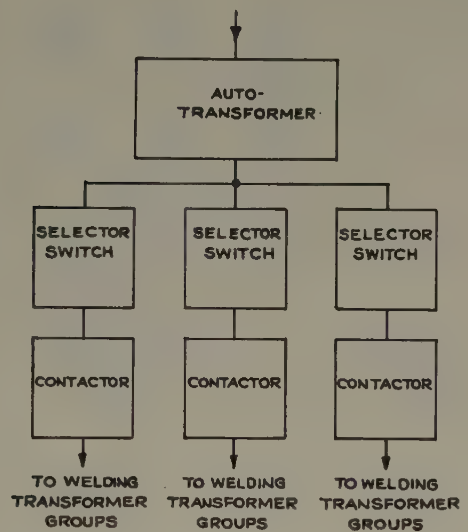


Figure 3. Voltage control by autotransformer method

during the weld may be considered negligible for practical spot spacings. In practice, due to alignment considerations, it usually is necessary to use a 5/8-inch diameter flat electrode on one side; this does increase leakage somewhat on the flat electrode side, but not sufficiently to interfere with the practical application of this process.

4. *Polarity Considerations.* When producing multiple spot welds simultaneously, it is essential that proper polarity relations exist between adjacent electrodes. In general it may be stated that adjacent electrodes connected to separate transformer secondaries shall be of the same polarity if on the same side of the assembly. The application of this rule to series-, direct-, and opposed-secondary circuits is illustrated in Figure 8. When multiphase connections are used on a machine, the welding guns on a given phase should be grouped separately from those on another phase. Failure to observe polarity requirements will produce considerable differences between adjacent welds under production operating conditions.

5. *Secondary Impedance Characteristics.* In the interest of reducing primary current requirements and welding transformer size, the secondary impedance should be kept to a practical minimum. In order to maintain weld uniformity, secondary circuits controlled by a common voltage regulator should be of approximately the same impedance.

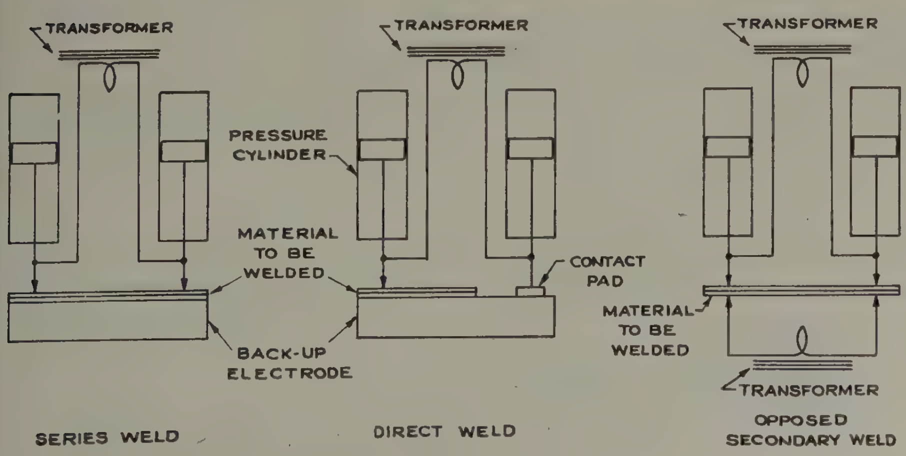


Figure 4. Typical secondary circuit arrangements

Typical series-weld secondary-circuit impedances vary from 350 micro-ohms with 78-per-cent power factor when using 18-inch-long 750,000-circular-mil cables at 4-inch spot spacing to 250 micro-ohms with over 95-per-cent power factor when using 8-inch-long 600,000-circular-mil cables and 2-inch spot spacing (welding 0.035-inch steel-reinforced cable).

One of the most significant factors in the impedance of series-weld secondary circuits, is the sheet metal and its associated contact resistance. In view of this fact, particular attention should be given to the effect of the

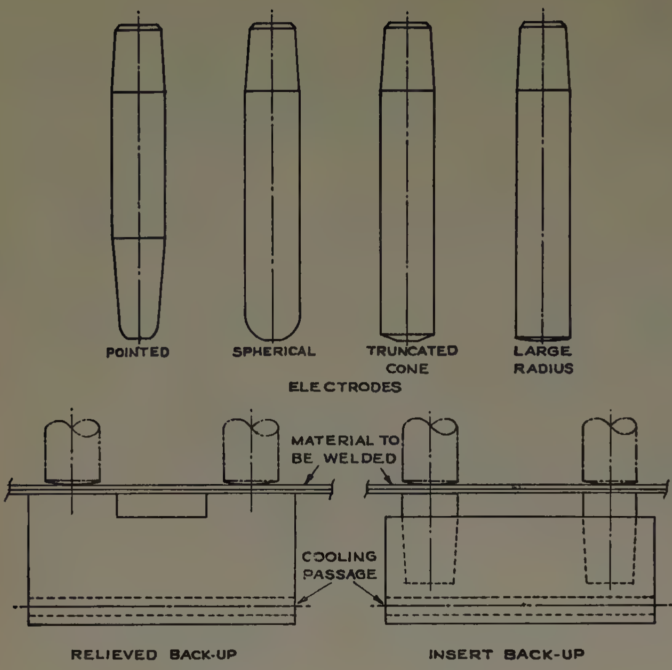


Figure 6. Typical welding electrodes and backups

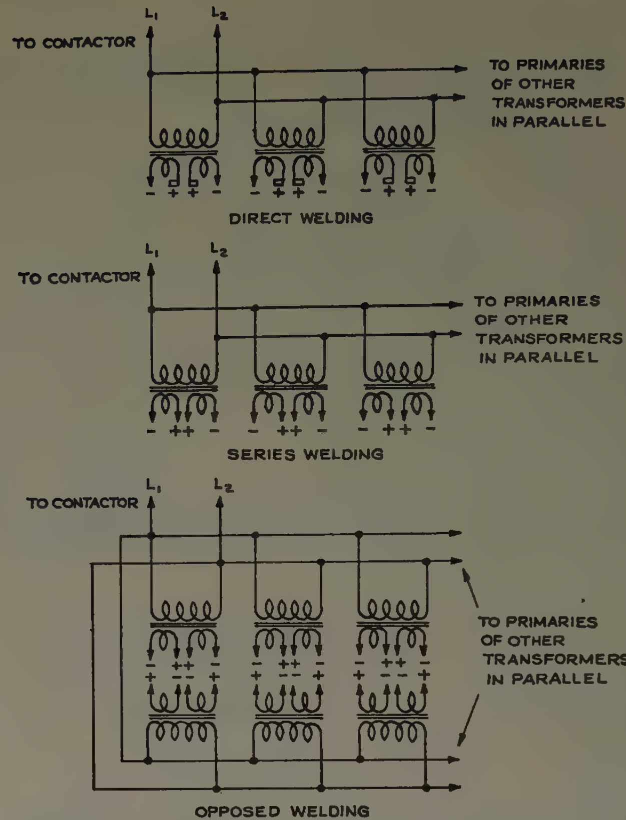


Figure 8. Polarity requirements

sheet metal when making welding current measurements. In many spot-welding shops it has been common practice to take primary current readings without steel between the welding electrodes and then calculate the secondary current using a correction factor of 10 to 15 per cent to compensate for the welded metal. The following example illustrates the possible error that might occur if this method were used in a typical series-welding application:

Welding Transformer: 96 to 1 ratio. Two secondaries in parallel.

Primary resistance	0.22 ohm
Primary reactance	0.26 ohm
Line voltage	440 volts

Secondary circuit: 8-inch long 600,000-circular-mil cables. Electrode spacing 2 inches 0.035 to 0.035 inch being welded.

	With Sheet Metal	Without Sheet Metal
Primary current	302 amperes	603 amperes
Current per secondary	14,500 amperes	29,000 amperes

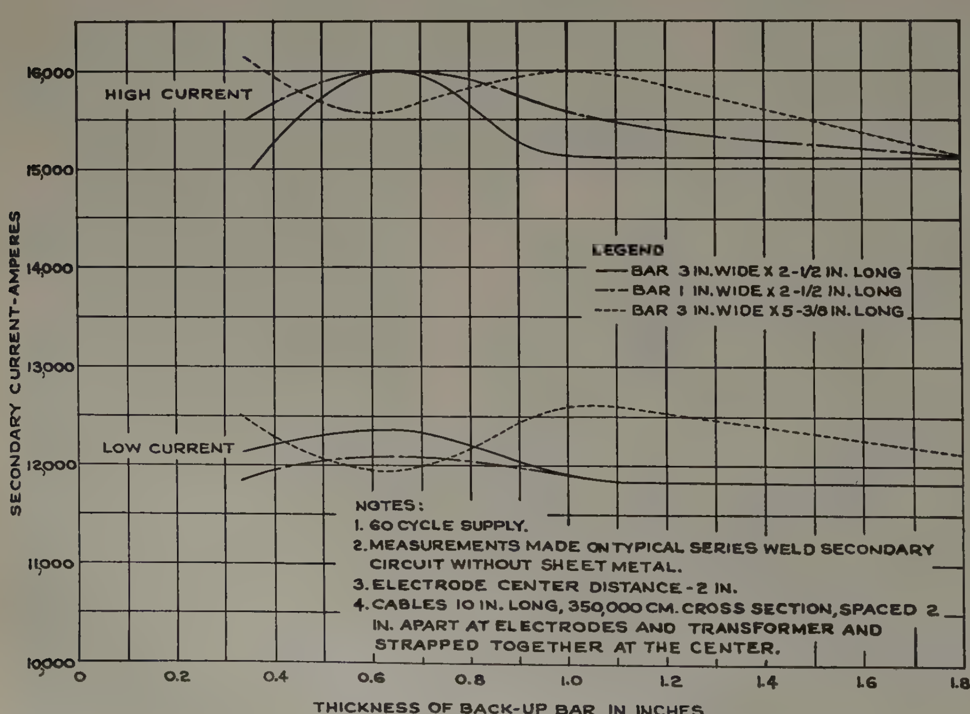


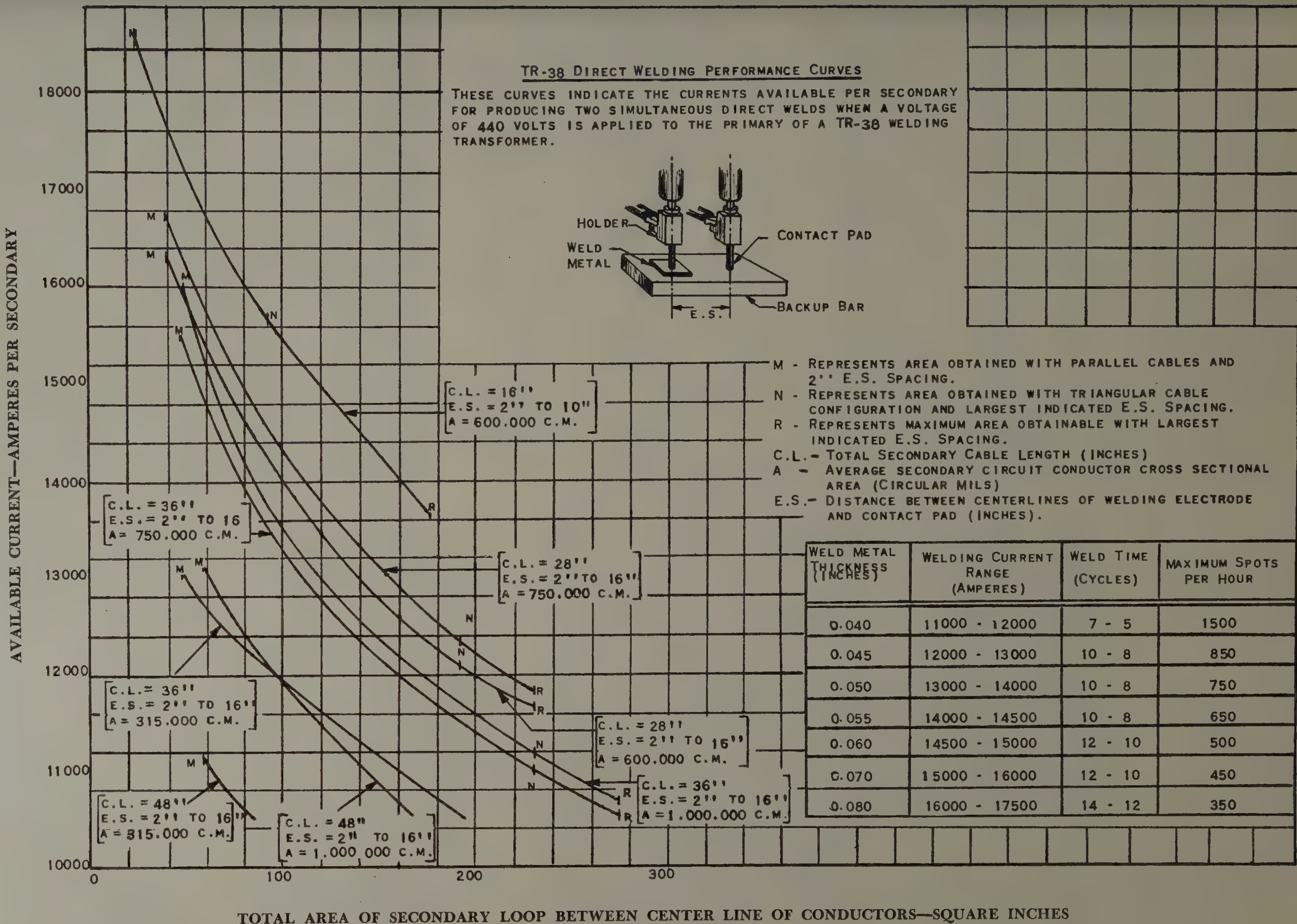
Figure 7 (left). Effect of back-up bar size on secondary current in series welding

It therefore is recommended that all current readings on presswelders be taken while stock is in the process of being welded.

Utilizing experimental data obtained on typical circuits, Figure 9 provides a chart prepared as a ready reference for the welding-machine designer for selecting equipment and making the electrode layout.

PRESSURE HEADS

Although spring or air-cylinder loaded devices are sometimes used, oil-actuated cylinders are generally



Weld Metal Thickness (Inches)	Welding Current Range (Amperes)	Weld Time (Cycles)	Maximum Spots per Hour
0.040	11000 - 12000	7 - 5	1500
0.045	12000 - 13000	10 - 8	850
0.050	13000 - 14000	10 - 8	750
0.055	14000 - 14500	10 - 8	650
0.060	14500 - 15000	12 - 10	500
0.070	15000 - 16000	12 - 10	450
0.080	16000 - 17500	14 - 12	350

Figure 9. Direct welding performance curves

preferred as they are compact, independent of electrode wear, may be retracted easily for part clearance, and do not load the platen while in motion. Figure 5 illustrates a typical construction with attached electrode holder. The hydraulic power system for cylinder operation should have rapid follow-up characteristics to prevent loss of pressure during the weld.

WELDING ELECTRODES

1. Conventional Class number 2 alloy water-cooled tips are generally used in either 1/2-inch or 5/8-inch diameter. Typical tip contours are shown in Figure 6. Our experience has shown that a $1^1/_2$-inch radius produces the best welding results on mild steel in the 0.030 to 0.090 inch thickness range. In view of the relative inaccessibility of many tip locations, a nonlocking taper (6 or 8 degrees including angle) frequently has been utilized in place of the more usual Morse taper on the holder end.
2. In the design of the stationary or backup electrodes, either inserts or lands are used at the weld location. Solid backups following the contours of the panel are very satisfactory when new, but present an excessive "tuning problem" when localized wear occurs. If short inserts are used, they may be indirectly cooled by the water passages in the holder. While investigating the effects of series-welding backup electrode geometry, some very interesting observations were made. Figure 7 illustrates the effect of varying the width, length, and thickness of the backup electrode when using a single pair of electrodes at 2-inch center distances. Although this effect is intriguing from a theoretical point of view, it has not been possible yet to take full advantage of this phenomena in practical designs.

STOCK THICKNESS LIMITATIONS

When direct or opposed secondary circuits are used, the presswelding of mild steel in thicknesses up to 0.100 inch is quite practical. Although greater thicknesses may be series welded under ideal conditions, in practice considerable trouble is frequently encountered when thicknesses over 0.050 inch are exceeded on the hot electrode side. Although results may be improved by increasing weld spacing, the maintenance of good part fitup becomes a major problem. The stock on the backup electrode side may be two to four times the thickness of the thinner sheet.

WELD SPACING

When using direct or opposed secondary welding methods, the spacing in a series of welds is usually determined by the electrode holder and pressure cylinder construction. A common practical minimum is $1^1/_2$-inch centers.

When series welding, the shunt current effect determines the practical minimum spacing. Figure 10 gives an indication of the effect of weld spacing on useful weld current for various metal thicknesses. A spacing of $1^1/_2$ to 2 inches has been found to be a good practical minimum.

ELECTRODE FORCE

To avoid excessive current requirements and excessive indentations, series presswelds are usually made with approximately one-half the electrode force recommended by American Welding Society (AWS) for direct welding.

AWS force recommendations are well suited to direct or opposed secondary presswelds. When conditions permit increasing weld time, somewhat lower forces may be used with lower currents.

WELDING CURRENT

Series welds require approximately 110 per cent of AWS recommended current values (for direct welding) when using 50 per cent of force and 100 to 125 per cent of

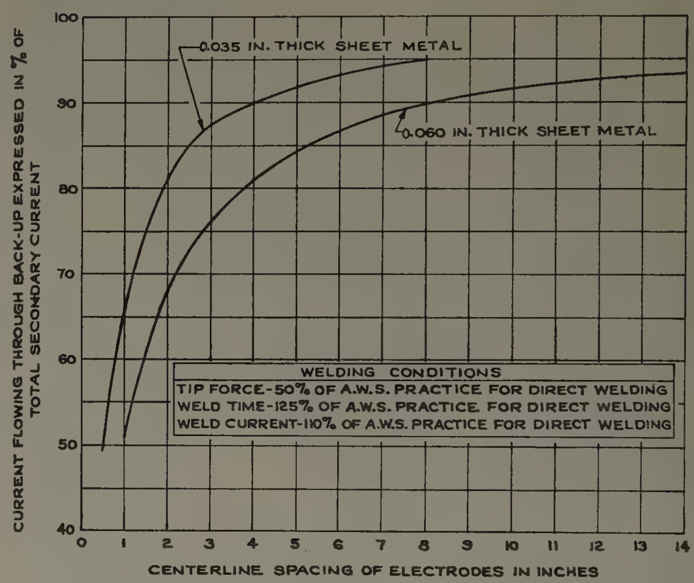


Figure 10. Effect of spot spacing on series welds

weld time recommendations. Although series-weld currents may exceed direct-weld current values by 10 or 15 per cent, each circuit produces two welds; thus actual primary current per weld may be only 55 or 60 per cent of the direct-weld requirements.

WELD TIME

Using electrode force and weld currents described in the foregoing, the most consistent series welds are produced when relatively long weld times are used—from 100 to 125 per cent AWS direct-weld standards appear quite satisfactory. When making direct or opposed secondary presswelds, AWS standard times are satisfactory.

To the best knowledge of the author there has been very little published information on presswelding practices. Undoubtedly there will be many who will not agree entirely with the context of this article, but it is to be hoped that it will result in some new and profitable investigations.

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A Magnetic Amplifier for Synchros

R. L. VanALLEN

THIS SYNCHRO magnetic amplifier was developed at the Naval Research Laboratory* as a demonstration of a system utilizing magnetic amplifiers of a type developed at the Laboratory. In this particular application the amplifiers perform the function of error sensing by delivering output power proportional to the difference between the stator terminal voltages of generator and motors. This is in one respect similar to operating a number of synchro motors from one large synchro generator; however, in other respects this similarity ends.

A single synchro generator is coupled to a number of synchro motors by 6 full-wave magnetic amplifiers as shown in the block diagram, Figure 1. The dotted arrows indicate inductive coupling between the control winding and the power winding of each magnetic amplifier; there is no direct electric connection. Two amplifiers are used for each pair of stator terminals and connected in such a way as to accommodate the change in polarity of stator terminal voltage when the rotor is displaced 180 degrees. Each amplifier, A, A', B, B', C, and C', is identical to that shown in Figure 2, having control circuits connected to the synchro generator and having load circuits connected to appropriate terminal of the synchro motors. Voltages E_{ac} and E'_{ac} are 60-cycle supplies obtained from separate windings of a power transformer. The control circuit of each magnetic amplifier has a constant current source, i, and rectifier, R_1 and R_2, to insure that current in the control circuit will not exceed magnetizing current of the core. In the load circuit, during the time the core is saturated, the loop impedance is low, to allow large currents in the stator windings of the motors. Thus, large torques may be exerted by the various motor shafts and at the same time essentially zero torque will be exerted by the generator shaft. This effective torque isolation between generator and motors allows input torque requirements to be of the order of magnitude necessary to overcome friction in the generator shaft alone. Limiting the generator current permits the use of generators of small physical size; in fact, the generator may be smaller than any of the motors in the load circuit.

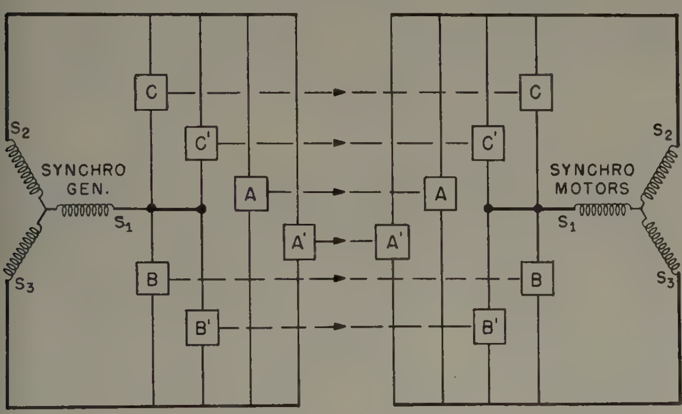

Figure 1. Block diagram of synchro magnetic amplifier

The operation of this type of magnetic amplifier depends upon the use of magnetic materials possessing a "square" hysteresis loop. Despite this, satisfactory results were obtained with the system when the core material used was Hypersil, for which the ratio of remanent to saturation flux is approximately 0.85 and is not considered a particularly "square" loop material. The response time of the amplifiers was found to be 1.2 cycles. Static accuracy (measured point by point) with 18 repeaters positioned via the magnetic amplifier was as good as that obtained from a single synchro generator positioning a single synchro motor connected directly. The results from dynamic accuracy measurements were influenced by the response time of the amplifiers. Since the amplifiers have a response time of 1.2 cycles there is a corresponding decrease in dynamic accuracy with increased speed of rotation. For example, with a response time of 1.2 cycles there is an inherent lag of 0.02 second which at 36 degrees per second causes the motors to lag 0.72 degree. Similarly a speed of rotation of 18 degrees per second introduces a lag of 0.36 degree. Transients introduced in either the generator or motors caused the same number of overshoots as that obtained with a motor-generator pair connected directly without magnetic amplifiers.

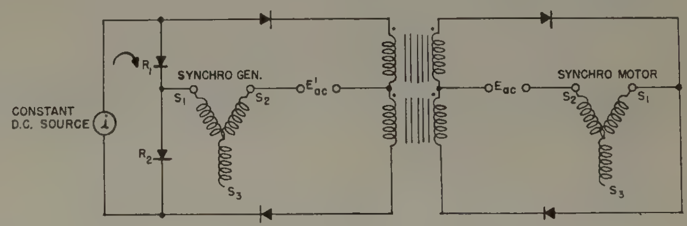

Figure 2. Full-wave synchro magnetic amplifier

REFERENCES

1. On the Mechanics of Magnetic Amplifier Operation, **R. A. Ramey.** AIEE *Transactions*, volume 70, part II, 1951, pages 1214–23.

2. On the Control of Magnetic Amplifiers, **R. A. Ramey.** AIEE *Transactions*, volume 70, part II, 1951, pages 2124–8.

3. The Single-Core Magnetic Amplifier as a Computer Element, **R. A. Ramey.** AIEE *Transactions*, volume 71, part I, 1952, pages 442–6.

* Invented by Dr. R. A. Ramey, formerly of the Naval Research Laboratory, now associated with the Westinghouse Electric Corporation.

Digest of paper 53-339, "A Magnetic Amplifier for Synchros," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Pacific General Meeting, Vancouver, British Columbia, Canada, September 1–4, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Diesel-Electric Locomotives in Canada

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MEMBER AIEE

D. F. HANEY
ASSOCIATE MEMBER AIEE

THE Canadian National Railways and the Canadian Pacific Railway are the two principal railway systems in Canada, with over 40,000 miles of track from the Atlantic seaboard to the Pacific Coast, and comprising the two largest railway systems on the North American continent. Although there are other Class I railroads operating in Canada, this article will limit the discussion to the two roads which operate about 95 per cent of the total track mileage.

The Canadian railways were the first to operate a diesel-electric locomotive in main-line service on this continent. Canadian National *9000*, placed in passenger service in 1928, was comprised of a 2,660-horsepower diesel-electric locomotive of two units, the largest in the world for many years. This locomotive was built by the Canadian Locomotive Company at Kingston, Ontario, using 800-rpm Beardmore engines built in Scotland, and Westinghouse electric equipment built in the United States. This was an experimental locomotive. The units accumulated a quarter of a million miles in revenue service and were retired in 1946 because spare parts became unavailable.

The number of units has increased from five totaling 4,710 horsepower at the end of 1942, to 610 totaling 728,750 horsepower at the end of 1952. The diesel-electric units of the two railways have accumulated 96,000,000 miles in service to the present time. Of that total, 50,000,000 miles were accumulated in switching service and 46,000,000 miles in road service; the latter since 1948 when the first road units were purchased.

Some of the electrical problems in Canada which may not be typical elsewhere on this continent are those caused by fine dry powdered snow blown by high winds so common in the extreme cold. This snow will pass through filters to build up to a foot and more in the interior passageways of the locomotive and will enter the main generator, traction motor blowers, and electric control compartments. This results in frequent moisture grounds which are alleviated partially by continuing the operation of the locomotive so that the electric equipment is dried out by its own generated heat.

Figure 1. Canadian National Locomotive *9000*, the first diesel-electric locomotive in main-line service in North America

Late in the fall the locomotives are winterized to restrict the entry of powdered snow to the most critical areas of the engine room. Up to 50 per cent of the car body filters are blocked off to reduce the amount of cooling air entering the engine room. Exhaust openings from the main generator to the outside are closed so as to use recirculated air rather than fresh air which carries snow with it.

To take advantage of the relatively snow-free air above the locomotive some units have a roof air intake placed over one of the engine cooling radiator blowers and so baffled that some of the exhaust from the radiator blowers is drawn into the engine room with the outside air taken in at this point. The control temperature of this radiator blower is set to have it operate first and so supplement the outside air with preheated air whenever heat is available from the engine cooling radiators. The amount of air drawn through the roof intake will depend upon how many car body filters are blocked off and whether the engine-room shutters are open or closed.

In passing, it may be significant to note that the original Canadian National *9000* had some features not yet available on modern diesel-electric power on this continent. Engine air could be taken either directly from the outside or from inside the engine room, depending upon climate and track conditions. This had the advantage that when air was taken directly from the outside the amount of snow drawn into the engine room was much less. The generator was enclosed in a separate compartment, and thus was free from snow and oily vapor deposits.

Precautions are taken in cold weather to inspect locomotives indoors as soon as possible after being released from service. The electric equipment, therefore, does not cool down to the point where condensation would occur across insulated parts when subsequently brought into the shops.

The only schedule for traction motors is the inspection and cleaning up at wheel change. This has been satisfactory to date but insufficient experience has been obtained to establish a definite overhaul interval. The first of the diesel-electric yard switchers recently marked 10 years of service. The first of the diesel-electric road locomotives recently completed 600,000 miles of operation in freight service. A definite pattern of life expectancy of traction motor bearings is developing on some of the power. This more than anything else is dictating when the traction motors are taken into the main shops for whatever overhaul is required. Road failures of traction motors have been mostly due to mechanical failures and accidents.

Digest of paper 53-68, "Diesel-Electric Locomotives in Canada," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

J. D. Sylvester is with Canadian National Railways, Montreal, Quebec, Canada, and D. F. Haney is with Canadian Pacific Railway Company, Montreal, Quebec, Canada.

Kansas City Section Anticipates Large Attendance at Fall Meeting

Kansas City, Mo., was chosen for the AIEE Fall General Meeting during the week of November 2–6, 1953, because it is located centrally and is reached easily from all parts of North America. It will give AIEE members and their wives a chance to attend a national meeting and to participate in the affairs of the Institute. The AIEE Kansas City Section has plans for taking care of a large attendance and promises a social and entertainment program in conjunction with the excellent technical program. Headquarters for the meeting will be in the Hotel Muehlebach.

The Fall General Meeting is expected to be an outstanding technical meeting of the year because of the large variety of papers which are scheduled. Special attention is being given this year to the electrical phase of the petroleum industry. As may be seen in the program other papers will cover subjects in many fields of the electrical industry. Of note are three sessions on computing devices, two on the mining industry, and two on television and aural broadcasting. In the Power Division two sessions each also are scheduled on power generation and system engineering.

The first speaker in the session on management will be P. F. Drucker, author of several books and a consultant on the problems of management organization and human relations. His talk will be on the subject "How Should a Manager Spend His Time?" The second speaker will be L. A. Russ, director of management development, Westinghouse Electric Corporation, who will speak on "The Implementation of a Management Development Program."

The Fall Meeting will provide a chance to meet with the national, District, and Section officers. There will be a meeting of the Board of Directors on Thursday. C. Myron Lytle, Vice-President, District 7, also has called an Executive Meeting for the officers of the South West District.

GENERAL SESSION

C. G. Roush, Fall General Meeting chairman, will open the meeting on Monday forenoon. Mayor William E. Kemp will extend a welcome to the convention and an outstanding speaker will present a worthwhile talk. AIEE President Elgin B. Robertson will talk on the affairs of the Institute.

INSPECTION TRIPS

Arrangements have been made for the following trips to industries in Kansas City and vicinity. Every effort has been made to bring out the technical aspects of each trip. In addition, they will afford the members attending an opportunity to see Kansas City.

Platte Pipe Line Company dispatches its flow of oil over a new 1,056-mile pipe line and uses supervisory control of the pumping stations by microwave from an office in the Power and Light Building. The dispatcher's control room and microwave equipment will be shown.

Hawthorn Power Plant of Kansas City Power and Light Company is a new steam-electric generating station with two 66,000-kw and one 99,000-kw units in operation. There is one 99,000-kw unit under construction.

WDAF-TV of the Kansas City Star has a new building which includes all of its program, studio, commercial, communication, power, and operating facilities. It is a 100,000-watt visual effective radiated power station.

Sheffield Steel Corporation has one of the largest steel plants in the Midwest and has many items of interest to engineers. A new 100-ton electric furnace rated 25,000 kva is in use. It is one of the largest in the Midwest. The rod and merchant mill is an example of automatic steel making.

The BOP Plant of General Motors Corporation is an assembly plant in which Buicks, Oldsmobiles, and Pontiacs are assembled and finished on the same line.

Tour of Kansas City. The Grayline bus will tour Kansas City and cover points of interest. This tour will be available to members and their wives.

This building houses station WDAF-TV of the Kansas City Star, where visitors to the Fall General Meeting may inspect radio and television equipment

SOCIAL AND ENTERTAINMENT

Arthur C. Kirkwood, chairman of the committee, promises good entertainment for the evening hours.

At the informal social hour on Sunday evening for members and their wives, early arrivals can become acquainted.

The stag smoker will give members and their guests an opportunity to relax and enjoy themselves. There will be cocktails, buffet dinner, and entertainment.

Members attending the meeting have been invited to be paying guests at the Chamber of Commerce luncheon on Wednesday, as an aid toward promoting professional relations.

At the dinner-dance on Wednesday evening, members and their wives can enjoy a good dinner, entertainment, and dancing in the magnificent new Grand Ballroom at Hotel Muehlebach. Formal dress will be optional.

Golfers will find many fine country clubs in Kansas City and guest tickets will be provided for those wishing to play.

Ladies' Program. Mrs. Samuel H. Pollock and her committee of 100 ladies have ambitious plans to keep the wives entertained. Through their wives the engineers will become acquainted, and the wives will enjoy themselves even more.

Get-acquainted coffee hours will be held on the mezzanine floor at Hotel Muehlebach starting at 10 a.m. each morning. All ladies should attend these to arrange for their activities for the day.

Tours of Kansas City will be arranged each day at the coffee hour to meet the diversified interests of the ladies. A tour of the city will be made Monday morning, and antique shops will be covered Thursday forenoon. Other tours will include shops, Nelson Gallery of Art, Kansas City Art Institute, Plaza shopping district, Hall Brothers gifts, and nationally known factories.

The Fashion Tea at the Emery Bird Thayer Store on Monday at 3 p.m. will include luncheon and fashion show.

On Tuesday evening, the ladies will meet at 8:30 p.m. in the Trianon Room of the Hotel Muehlebach for cards, followed by entertainment by Mrs. A. C. Kirkwood who will give a reading of a current Broadway hit.

A Bridge Luncheon at the Blue Hills Country Club on Wednesday noon is expected to be a highlight of the ladies' activities. They will play bridge, canasta,

Future AIEE Meetings

Conference on the Application of Motors to Air-Moving Equipment and Symposium on Induction Motors
Hotel Van Orman, Fort Wayne, Ind.
October 6–8, 1953

Conference on Machine Tools
Cleveland Hotel, Cleveland, Ohio
October 14–16, 1953

Textile Industry Conference on Electric Equipment
North Carolina State College, Riddick Laboratories Auditorium, Raleigh, N. C.
October 29–30, 1953

Fall General Meeting
Muehlebach Hotel, Kansas City, Mo.
November 2–6, 1953
(*Final date for submitting papers—closed*)

AIEE-IRE Conference on Electronic Instrumentation in Nucleonics and Medicine
New Yorker Hotel, New York, N. Y.
November 18–20, 1953
(*Final date for submitting papers—closed*)

AIEE-IRE-ACM Eastern Computer Conference
Statler Hotel, Washington, D. C.
December 8–10, 1953
(*Final date for submitting papers—closed*)

Winter General Meeting
Statler Hotel, New York, N. Y.
January 18–22, 1954
(*Final date for submitting papers—October 20*)

Scintillation Counters Conference
Washington, D. C.
January 26–27, 1954
(*Final date for submitting papers—October 26*)

Southern Textile Conference
A. French Textile School of Georgia Institute of Technology, Atlanta, Ga.
April 15–16, 1954
(*Final date for submitting papers—January 15*)

Conference on Feedback Control
Claridge Hotel, Atlantic City, N. J.
April 22–23, 1954
(*Final date for submitting papers—January 25*)

AIEE-IRE-REIMA-WCEMA Electronic Components Conference
Washington, D. C.
April 27–29, 1954
(*Final date for submitting papers—January 27*)

North Eastern District Meeting
Schnectady, N. Y.
May 5–7, 1954
(*Final date for submitting papers—February 4*)

Electric Welding Conference
Milwaukee, Wis.
May 19–21, 1954
(*Final date for submitting papers—February 19*)

AIEE-IAS-IRE-ISA Conference on Telemetering
Morrison Hotel, Chicago, Ill.
May 24–26, 1954
(*Final date for submitting papers—February 24*)

Summer and Pacific General Meeting
Los Angeles, Calif.
June 21–25, 1954
(*Final date for submitting papers—March 23*)

and pinochle for some very attractive prizes.

A Kansas City Museum tour and show has been arranged for Thursday afternoon. After a tour of the museum, a show will be staged in the costume wing entitled "Femininity of Yesteryear."

HOTELS AND REGISTRATION

The headquarters for the meeting will be Hotel Muehlebach located in the heart of the downtown area. For hotel reservations, address Miss Mary Nugent, Kansas City Chamber of Commerce, 1030 Baltimore, Kansas City, Mo. There are a number of fine hotels within a few blocks of Hotel Muehlebach and placement will be made according to the accommodations that are available at prevailing rates (see September issue, page 818, for room rates).

Advance registration cards should be sent in so that the committee will have an idea as to how many plan to attend; also, expected attendance at social functions and inspection trips should be indicated. Registration fees are $3.00 for members and $5.00 for nonmembers. There will be no registration fee for enrolled students and families of members.

FALL GENERAL MEETING COMMITTEE

The members of the General Committee for the 1953 Fall General Meeting are: C. G. Roush, chairman; Riley Woodson, vice-chairman; S. M. Pollack, secretary-treasurer; C. M. Lytle, Vice-President, District 7; J. C. Bibbs, J. E. Barfield, O. H. Johnson, C. M. Haynes, members-at-large. The subcommittee chairmen are J. P. Kesler, registration and hotel; William Carter, reception; L. M. Schindler, technical program; R. L. Baldwin, finance; A. C. Kirkwood, entertainment; H. E. James, inspection trips; M. J. Horney, publicity; L. L. Davis, transportation; O. L. Starcke, printing; W. P. Smith, students; and Mrs. S. H. Pollock, ladies.

Tentative Technical Program

Fall General Meeting, Kansas City, Mo.

Monday, November 2

10:00 a.m. General Session

2:00 p.m. Switchgear

53-404. Life of Silver-Surfaced Contacts on Repetitive Arcing Duty. *W. R. Wilson*, General Electric Company

53-405. System Recovery Voltage and Short-Circuit Duty for High-Voltage Circuit Breakers. *I. B. Johnson, A. J. Schultz, W. F. Skeats*, General Electric Company

53-149. New Line of Low-Voltage Air Circuit Breakers. *B. S. Beall, III, V. N. Stewart*, General Electric Company

CP.* Accessories for the Air Systems of Operating Mechanisms for Outdoor Oil Circuit Breakers. *W. C. Mitchell, V. L. Tilli*, General Electric Company

CP.* A Quality Control Program of Increased Scope on Power Circuit Breakers. *K. G. Darrow*, General Electric Company

2:00 p.m. Communication Switching Systems

53-403. The Diode Matrix as a Component in Relay Switching Circuits. *G. L. Bush*, Teleregister Laboratories

CP.* Automatic Percussive Welding. *A. L. Quinlan*, Western Electric Company, Inc.

53-407. Automatic Testing of Wired Relay Circuits. *A. N. Hanson*, Western Electric Company, Inc.

53-408. The Type 7 Crossbar Selector. *R. W. Hutton*, Kellogg Switchboard and Supply Company

2:00 p.m. Feedback Control Systems

53-392. Determination of the Maximum Modulus, or of the Specified Gain, of a Servomechanism by Complex-Variable Differentiation. *T. J. Higgins*, University of Wisconsin; *C. M. Siegel*, University of Virginia

53-394. Backlash in Velocity Lag Servomechanism. *N. B. Nichols*, Raytheon Manufacturing Company

CP.* A General Theory for the Determination of the Stability of Multiple-Loop Servomechanisms. *T. S. Amlie, T. J. Higgins*, University of Wisconsin

53-393. Bibliography on Feedback Control—Part III. *Subcommittees on Bibliography of the Committees on Industrial Control and Feedback Control Systems*

2:00 p.m. Instrumentation for Hospital Isotope Programs

CP.* I. Radiation—Sensitive Instruments (Geiger Tubes and Scintillation Devices). *F. E. Hoecker*, University of Kansas

CP.* II. Electronic Counting Instruments. *P. N. Wilkinson*, University of Kansas

CP.* Microabsorption Technics Using Photomultiplier Tubes. *G. G. Wiseman*, University of Kansas

CP.* An Automatic Method of Analyzing the Concentration of Anaesthetic Gases. *R. W. Krone*, University of Kansas

CP.* An Investigation of Metastable Levels in Gaseous Discharge Tubes. *Robert McFarland*, Kansas State College

Tuesday, November 3

9:30 a.m. Safety

CP.* Electrical Safety in a Large Development Laboratory. *G. L. MacLane, G. E. Stoltz*, Westinghouse Electric Corporation

CP.* Safety in the Utilization of Electricity on the Farm. *E. H. Smith*, Kansas City Power and Light Company

CP.* Precision Switches Used as Interlocks and Limits in Safety Controls. *A. L. Riche*, Minneapolis-Honeywell Regulator Company

CP.* Cost Control by Accident Control. *C. R. Zeskey*, T. H. Mastin Company

9:30 a.m. Industrial Power Systems

CP.* Natural Gas Plant Power Distribution Systems. *C. D. Catt*, El Paso Natural Gas Company; *J. K. Howell*, Westinghouse Electric Corporation

CP.* Grounded Versus Ungrounded System Operation in Industrial Plants—A Demonstration. *R. H. Kaufmann*, General Electric Company

CP.* Distribution Systems in Oil Refineries. *T. R. Shaw*, Phillips Petroleum Company

CP.* Power Generation and Distribution in Chemical Industries. *R. F. Lawrence, H. B. Thacker*, Westinghouse Electric Corporation

9:30 a.m. Petroleum Pipe Line

CP.* Selection of Motors and Controls for Pipe-

*CP: Conference paper; no advance copies are available; not intended for publication in *Transactions*.

Line Pumping Stations. *R. J. Osborn*, Sinclair Pipe Line Company

CP.* Automatic and Remote Control of Electric Pipe-Line Stations. *R. S. Cannon*, Plantation Pipe Line Company

CP.* Petroleum Microwave Progress 1950 to 1953. *E. B. Dunn*, Keystone Pipe Line Company

2:00 p.m. Aural Broadcasting

CP.* Design Principles and Fallacies in the High-Fidelity Field. *F. A. Slaymaker*, Stromberg-Carlson Company

CP.* Development and Practical Operating Considerations of the Conelrad System for Standard Broadcast. *A. P. Walker*, National Association of Radio and Television Broadcasters

53-414. Development of Television Service Standards and Application to Design of a Television Broadcast Network. *O. W. B. Reed, Jr.*, Jansky and Bailey, Inc.

CP.* Factors Affecting the Correlation of Television Picture Quality Between Field and Laboratory Signals. *B. Amos, C. Quirk*, Du Mont Corporation

2:00 p.m. Management

CP.* How Should a Manager Spend His Time? *P. F. Drucker*, Consultant

CP.* The Implementation of a Management Development Program. *L. A. Russ*, Westinghouse Electric Corporation.

2:00 p.m. Insulated Conductors

53-389. Pipe-Line Design for Pipe-Type Feeders. *R. C. Rifenburg*, Consolidated Edison Company of New York, Inc.

53-386. Submarine Cables. *Andrew Bodicky*, Union Electric Company of Missouri

53-390. Power Cable Crossings on Bridges and Viaducts. *D. C. Hawley*, Kansas City Power and Light Company

53-391. A Method of Analysis of Annual Variations of Harbor Water and Earth Temperatures. *W. N. McDaniel, E. F. Wolf*, Consolidated Gas Electric Light and Power Company of Baltimore

53-379. Pipe Losses in Nonmagnetic Pipe. *L. Meyerhoff*, General Cable Corporation

2:00 p.m. Petroleum Refining

CP.* Applications of Outdoor Metalclad Switchgear. *E. R. Hoyle*, Sinclair Refinery Company

CP.* Protection of Large Motors. *C. R. Olson*, Westinghouse Electric Corporation

CP.* Oil Versus Air Circuit Breakers for Petroleum Refineries. *W. B. Wilson, J. Erwin*, General Electric Company

Wednesday, November 4

9:30 a.m. Television

CP.* Investigation of Ultrahigh-Frequency Amplifier Operation. *W. Y. Pan*, RCA Victor Division

CP.* Review of Development of Color Television. *G. H. Brown*, RCA Laboratories Division

CP.* Beat Between Sound Carrier and Color Signal in a Television Receiver. *J. E. Allen*, General Electric Company

CP.* Unified Signal Coder for Compatible Color System. *J. F. Fisher, A. J. Anderson*, Philco Corporation

9:30 a.m. Eastern Mining

CP.* Electrical Engineering Aspects of the Electrocarbonization of Coal. *E. Sarapuu*, Sinclair Coal Company; *P. C. Cross*, General Electric Company

CP.* St. Joseph Lead Company Development at Missouri. *W. H. Tucker*, St. Joseph Lead Company; *D. E. Cain*, General Electric Company

CP.* Electric Equipment of Electrolytic Zinc and Copper Production. *E. C. Clark*, General Electric Company

CP.* Protective Devices Underground. *A. J. Stoll*, I-T-E Circuit Breaker Company

—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES of papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Operations Committee ultimately will be published in the bimonthly publications and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

9:30 a.m. Petroleum Production

CP.* The Economic Aspects of Electric Oil Well Pumping. *T. L. Scott*, Phillips Petroleum Company

CP.* Complete Automatic Operation of Field Leases. *N. W. Beaudreau*, Central Power and Light Company

CP.* Oil Field Transmission and Distribution Systems. *J. R. Ashley*, Magnolia Pipe Line Company

2:00 p.m. Western Mining

CP.* Ore Conveyors at Pend O'Reille Mines and Metal Corporation. *R. M. Gilbert*, Spokane, Wash.

CP.* Arc Furnaces in Mining Industry. Canadian General Electric Company

CP.* A 6,000-Horsepower Automatic Mine Hoist Drive. *L. W. Fisher, F. C. Dohaney*, Canadian General Electric Company

2:00 p.m. Transmission and Distribution

53-399. Abnormal Voltage Conditions Produced by Open Conductors on 3-Phase Circuits Using Shunt Capacitors. *P. E. Hendrickson, I. B. Johnson, N. R. Schultz*, General Electric Company

53-400. Electromagnetic Unbalance of Untransposed Transmission Lines. *E. T. B. Gross, M. H. Hesse*, Illinois Institute of Technology

53-401. Electrostatic Unbalance to Ground of Twin Conductor Lines. *E. T. B. Gross, W. J. McNutt*, Illinois Institute of Technology

53-402. Sequence Networks for Faults on Open-Y-Open-Delta Transformer Banks. *L. C. Caverley*, University of Minnesota; *J. V. Sastry*, Northern States Power Company

CP.* Application of Shunt Capacitors to Network Systems. *H. Brooks*, Westinghouse Electric Corporation

53-415. Bibliography on Power Capacitors 1951-52. *Capacitor Subcommittee of the Committee on Transmission and Distribution*

2:00 p.m. Radio Communication Systems

53-384. A Miniature Compandor for General Use in Wire and Radio Communication Systems. *F. S. Boxall, R. S. Caruthers*, Lenkurt Electric Company, Inc. Re-presented for discussion

53-381. Use of Radio and Radar in the Petroleum Industry. *W. M. Rust, Jr.*, Humble Oil and Refining Company

53-382. Microwave as Applied to Railroad Operation in the Gulf Coast Area. *L. R. Thomas*, Atchison, Topeka and Santa Fe Railway Company

CP.* Industry Co-ordination of Microwave Communications Systems. *Victor Nexon*, Federal Telephone and Radio Corporation

2:00 p.m. Cathodic Protection

CP.* The Advantage of Using Zinc or Zinc-Coated Metals Underground to Conserve Cathodic Protection Current. *O. C. Mudd*, Shell Pipe Line Company

53-413. A Discussion of the Detroit Committee on Electrolysis. *R. L. Rayner*, Michigan Bell Telephone Company

CP.* Magnetic Amplifier Control of Cathodic Protection Equipment. *Daniel Werner*, American Telephone and Telegraph Company

Thursday, November 5

9:30 a.m. Power Generation

53-388. Protection of Turbine-Generators and Boilers by Automatic Tripping. *H. A. Bauman, J. M. Driscoll, P. T. Onderdonk, R. L. Webb*, Consolidated Edison Company of New York, Inc.

53-406. Long Island Lighting Company's Glenwood Number 3 Outdoor Power Station. *W. J. Burns, E. F. DeTurk*, Long Island Lighting Company

CP.* Electrical Features of Eastlake Generating Station. *C. F. Paulus*, Cleveland Electric Illuminating Company

CP.* Electrical and Mechanical Features of the Niles Generating Station. *C. E. Asbury, J. C. Beres*, Commonwealth Associates

CP.* Maximum Short-Circuit and Faulty Synchronizing Torques on Generator Foundations. *V. W. Ruskin*, Toronto, Ontario, Canada

9:30 a.m. Computing Devices

CP.* Use of High-Speed Computing Devices in Photometric Calculations. *G. A. Horton*, Westinghouse Electric Corporation

CP.* An Electronic System for Processing Air Traffic Control Information. *R. M. Kalb*, Engineering Research Associates, Inc.

53-409. Nondestructive Sensing of Magnetic Cores. *D. A. Buck, W. I. Frank*, Massachusetts Institute of Technology. Re-presented for discussion

CP.* A Sine Function Resistor. *K. L. Nielsen*, United States Naval Ordnance Plant; *E. H. Roland*, General Motors Corporation

9:30 a.m. Transformers and Protective Devices

53-385. Duplex Current-Limiting Reactors, Their Application and Forces. *L. E. Sauer*, Westinghouse Electric Corporation

CP.* Step-by-Step Calculation of Transformer Hot-Spot Temperature From Daily Load Curves. *G. H. Halsey*, General Electric Company

CP.* Transformer Noise Problem and Its Associated Model Studies. *T. D. Gordy, B. Gettys*, General Electric Company; *B. M. Carothers*, Union Electric Company of Missouri

CP.* A Stray Loss Problem in Transformer Tanks. *E. J. Adolphson, F. J. Vogel*, Allis-Chalmers Manufacturing Company

53-398. Grounding Electrode Characteristics From Model Tests. *H. R. Armstrong*, Detroit Edison Company

2:00 p.m. Power Generation

CP.* Turbine-Generators—Present and Future. *E. H. Krieg*, Stone and Webster Engineering Corporation

CP.* Internal Combustion Engines. *L. B. Immele*, Burns and McDonnell Engineering Company

CP.* Steam Generators. *G. V. Williamson*, Union Electric Company of Missouri

CP.* **Gas Turbine-Generators.** *C. F. Kottcamp,* Gulf Oil Corporation

2:00 p.m. Computing Devices

CP.* **Conversion Problems Incidental to the Use of a Digital Computer to Control Analogue Equipment.** *S. J. O'Neil,* Air Force Cambridge Research Center

CP.* **Digital Recording of Analogue Data.** *J. C. Hosken,* Arthur D. Little, Inc.

CP.* **Synchro-to-Digital Converter.** *C. D. Cockburn,* General Electric Company

CP.* **Design and Performance of a New Electromagnetic Analogue-Digital Converter.** *T. A. Feeney,* Coleman Engineering Company

2:00 p.m. System Engineering

CP.* **A Suggested Training Approach to the Incremental Method of Loading Generating Units.** *R. T. Purdy,* Commonwealth Edison Company

CP.* **Practical Consideration of Transmission Losses in System Operation.** *T. W. Schroeder,* Illinois Power Company

53-396. **Pacific Northwest 1952 Power Shortage.** *J. P. Jolliffe,* Bonneville Power Administration

53-380. **A System Operator's View of Ice Melting on a Power Line While in Service.** *O. L. Oehlwein,* Public Service Company, Division of Commonwealth Edison Company

53-337. **Experience and Reliability of Carrier Relaying Channels.** *AIEE Project Subcommittee Number 5, AIEE Committee on Carrier Current.* Re-presented for discussion

Friday, November 6

9:30 a.m. System Engineering

53-383. **Interconnected Systems Energy Accounting Procedure and Related Operating Practices.** *M. J. Lacopo,* American Gas and Electric Service Corporation. Re-presented for discussion

53-397. **Economy Loading Simplified.** *J. B. Ward,* Purdue University

CP.* **Switching Methods on a High-Voltage Cable System.** *E. L. Michelson, C. McNamara,* Commonwealth Edison Company

53-387. **Field Excitation in Relation to Machine and System Operation.** *S. B. Farnham, R. W. Swarthout,* General Electric Company

9:30 a.m. Computing Devices

CP.* **Analogue Computer Stability Studies of an Oil Field Pressure Maintenance System.** *S. J. Jennings, E. C. Clark,* General Electric Company

53-410. **The Use of Electric Network Analyzers for Pipe Network Analysis.** *R. E. Stephenson,* University of Utah; *J. R. Eaton,* Purdue University

53-411. **An Analysis of an Analogue Solution Applied to the Heat Conduction Problem in a Cartridge Fuse.** *A. E. Guile,* Queen Mary College; *E. B. Carne,* Remington Rand, Inc.

53-412. **The Solution of Sturm-Liouville Problems by D-C Network Analyzer.** *G. W. Swenson, Jr.,* Washington University. (Presented by R. E. Horn)

53-395. **Solution of Boundary-Value Problems on Automatic Computing Equipment.** *F. M. Verzuh,* Massachusetts Institute of Technology. Re-presented for discussion

Pacific Meeting Emphasizes Industrial Growth and Development of the Northwest

Papers presented at the AIEE Pacific General Meeting which was held in Vancouver, British Columbia, Canada, September 1–4, 1953, emphasized the unusual industrial growth and important developments taking place in the Northwest. A full program of 19 sessions, inspection trips, a dinner-dance and banquet, special events for the ladies, and a golf tournament took place, with headquarters at the Hotel Vancouver. The meeting was attended by more than 750 members and guests.

On the business side, an important meeting of the Board of Directors was held on Thursday preceded by a special meeting of Vice-Presidents and a District Executive Committee meeting.

OPENING SESSION

One of the features of the Pacific Meeting was the opening session at which three important addresses served as an appropriate introduction to the program to follow. Each of the speakers was introduced by the general chairman, J. H. Steede.

A cordial welcome to the city to friends in the United States and in different parts of Canada was extended by Mayor Fred Hume of the City of Vancouver. The mayor, who is an engineer, outlined recent municipal developments in the city: a new bridge, post office, and customs buildings, and plans for a new library, auditorium, many hospitals, and schools. Vancouver, which has an all-year port, is growing very rapidly and new pulp and paper mills are under construction.

A friendly welcome on behalf of industry was extended by AIEE Vice-President Ingledow, who is vice-president and chief engineer of the British Columbia Electric Company. Mr. Ingledow's remarks were for the benefit of those visiting the Vancouver section of Canada for the first time, to acquaint them with the area's industrial growth and expansion.

He explained that the primary industries for many years have been lumber, mining, agriculture, and fisheries. As a part of Canada's war effort, secondary industries came into being which since have been developed further and now supplement the economy. In the mining and metallurgical field, the Consolidated Mining and Smelting Company at Trail and Kimberly has become one of the largest operations of its kind producing base metals, fertilizers, and kindred products which are shipped to all parts of the world. Some 450 miles up the coast from Vancouver, the Aluminum Company of Canada is constructing a vast project which, when completed, will have a capacity equalling that of the Grand Coulee. As a further illustration of the section's phenomenal growth, the British Columbia Electric Company, Ltd., had an installed capacity of 249,000 horsepower in hydroelectric power before the war which has been increased to 605,000 horsepower in operation today, with another 120,000 horsepower projected for completion by 1955. Since 1949 almost 1,000,000,000 kilowatt-hours of energy have been exported to the network in the northwest United States.

With regard to water storage facilities of the Columbia-Kootenay system, Mr. Ingledow said that this has created a major political issue upon which the representatives of Canada and the United States are at present far from agreement. In negotiations concerning the initial reservoir for Libby Dam, the American representatives considered that it would be adequate compensation if cash payment were made to British Columbia for land flooded and property damaged as a result of such regulating works. On the other hand, the Canadian attitude has been that payment should be made in the form of a block of power commensurate with the contribution that storage in Canada will apply to downstream benefits. Mr. Ingledow expressed confidence that this attitude was not an unreasonable one and eventually would form the basis of a formula by which the differences between the two countries will be reconciled.

In reference to other accomplishments, Mr. Ingledow mentioned the high-voltage transmission line span slightly more than 2 miles long across Kootenay Lake which compares favorably with the projected crossing over the Straits of Messina, the British Columbia Electric Company's 345-kv transmission line, and the two large high-head generating units operated by remote supervisory and automatic control. In closing, tribute was paid the engineering

Mayor Fred Hume (left) of the City of Vancouver welcomes AIEE President Elgin B. Robertson at the opening general session of the Pacific General Meeting

Engineers representing Canada, England, and the United States inspect some of the electric power equipment in the Vancouver area. Left to right are: R. J. Brown, Moloney Electric Company, Toronto, Ontario, Canada; D. E. Lambert, A. Reyrolle and Company, Ltd., Hebburn-on-Tyne, England; and F.O.McMillan, Oregon State College, Corvallis

staffs of these projects, the benefits of Institute meetings, and the contributions as well as the work of the committee of the Vancouver Section which made the arrangements.

The concluding speaker, President Elgin B. Robertson, commented on Institute affairs. These were in fine shape with a membership of 46,682 as of August 1.

President Robertson pointed out that the Institute is operating with about a $1,000,000 budget for the present year and living within its income. The objective is not to accumulate a reserve; however, small balances and sundry funds from operations result at the end of the year. The effort of the Board of Directors is a most honest desire to conduct Institute affairs in the way desired by the members.

Concerning student enrollment, President Robertson asked each member to make a special effort to make sure that the advantages of Student membership were made known to the students.

Most of the Institute's problems were described as growing pains and President Robertson called attention to the difficulties of finding facilities for the increased number of sessions, the impossibility for several Vice-Presidents to visit most of their Sections, and the need for a larger staff and a new building commensurate with the growth in membership. He expressed the belief that Treasurer Walter J. Barrett has developed a plan and that a new building will be forthcoming in 4 or 5 years. The new bimonthly publications, *Power and Apparatus*, *Communication and Electronics*, and *Applications and Industry*, are one attempt to give better service to the membership.

In conclusion, President Robertson discussed co-operative efforts with other societies such as standards work, Engineers Joint Council, and so forth. He pointed out that the AIEE as such does not have a need for unity, but that the members and he desire it, and he assured his listeners that he would do everything possible to attain that objective.

STUDENT TECHNICAL SESSION

The Student Session was held on Tuesday afternoon. The following five papers were presented by the students:

1. "Measurement on a Nonlinear Ceramic Capacitor." S. V. Marshall, Oregon State College
2. "D-C Fish Shocker." Armon Eggan, University of Montana
3. "Sixty-Cycle Power From a 7,200-Rpm Alternator." Allan Marshall, University of Idaho
4. "Radiation Detection Instruments." R. G. Hyden, Washington State College
5. "Electronic Tide Control Equipment at the Fraser River Model." LeRoy Nelms, University of British Columbia

STUDENT BRANCH CONFERENCE

Following the Student technical session, an important and enthusiastic conference on Student activities in Districts 8 and 9 took place under the guidance of Professor J. H. Johnson, counselor at the University of Idaho. Each Student Branch chairman briefly reported on the operating procedures and activities of his Branch, with supplementary remarks from the counselors. The exchange of information proved both profitable and stimulating with indications of an increase in Student enrollment in several schools over the number enrolled in the last few years.

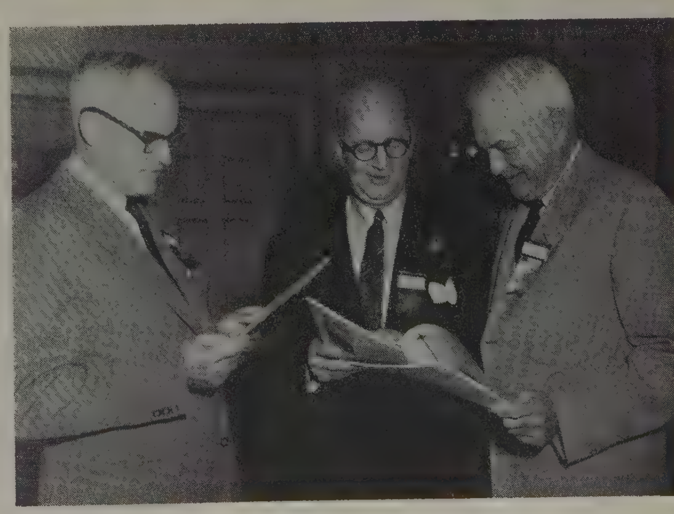
Most schools have local dues of 50 cents or a dollar to help defray expenses although one school reported that they encouraged full enrollment rather than local dues to avoid embarrassment such as the case where a student had won a paper prize contest only to find out that he was not a member. Most Branch meetings are held in the evenings, at 4 o'clock after laboratory, or at noontime, depending on local conditions and the competition presented by other activities. The open house, electrical shows, or demonstrations have proved very successful in several schools as this type of activity provides an incentive. Competitive activities such as teams racing against time to take a motor apart and slide-rule contests also proved successful. Field trips were popular and belief was expressed that they provide an opportunity for students to see operations and to talk with the men in industry. Several of the Branches made up parties and attended Section meetings and a few attended dinners of the Sections with the students' dinners paid for by the section. Social activities, picnics, and athletic contests also were reported as quite successful forms of activity.

The University of British Columbia reported no difficulty in obtaining student papers, as essays on summer projects are required as a part of the curricula. At the conclusion of the conference, Professor Johnson called the counselors together for a brief meeting.

TECHNICAL PAPERS AND SESSIONS

Many of the 65 papers which were presented in 19 sessions emphasized the great industrial growth and development which is taking place in the Northwest and quite naturally the emphasis was on hydroelectric generation. The electrical aspects of the Kemano-Kitimat Hydroelectric Power Development, with ultimate capacity the equivalent of that at Grand Coulee and with its underground powerhouse and many novel engineering features, evoked considerable interest. The presentation was made by F. L. Lawton of the Aluminum Laboratories, Ltd. Several of the unconventional features or designs were dictated by the severe climatic conditions and difficulties presented by shipping apparatus to the remote location. G. D. Floyd predicted in discussion that these unusual features would be talked about by engineers for years to come.

Another paper which marked pioneering engineering work was "The Wahleach Hydroelectric Development" by T. Ingledow and J. H. Steede of the British Columbia Electric Company, Ltd. A single 82,000-horsepower



Discussing plans for the Pacific General Meeting are, left to right: J. H. Steede, British Columbia Electric Company, Ltd., chairman of the meeting; AIEE Vice-President T. Ingledow, British Columbia Electric Company, who presented the welcoming speech on behalf of industry; and Elgin B. Robertson

unit operates under a 2,000-foot head. The unit is operated under supervisory control from the central office in Vancouver 72 miles away. Associated with this development but designed for later extension to the Bridge River Plant 110 miles northward is a 345-kv double-conductor designed transmission line, the first of its kind on the North American continent.

In a session on switchgear testing, the presentation and discussion of the paper, "Is the European Circuit Breaker Rating System Really More Conservative Than the American?" by R. C. Van Sickle, Westinghouse Electric Corporation, assumed international importance. It was discussed by three well-known engineers from Great Britain who were present to give their views: D. E. Lambert, A. Reyrolle and Company, Ltd.; V. A. Brown, Switchgear Testing Company, Ltd.; and T. M. Wilcox, Mers and McLellan, Consulting Engineers. Most of the discussion evolved about the question of symmetrical and asymmetrical testing. The presentation and the discussions brought about a better appreciation of the differences in the British and American methods of rating and testing air blast circuit breakers and oil circuit breakers.

In the power field, several other sessions dealt with relaying, microwave carrier, carrier current, transmission and distribution, and switchgear. In the communications field, there were two sessions on wire communications and papers on joint use of pole lines, a 170-megacycle radiation survey, and measurement of video interference. On the theoretical and scientific side there were sessions on basic sciences, feedback control systems, magnetic amplifiers, and electrical techniques in medicine and biology. Last but not least, to complete the picture were two chemical and electrochemical sessions with papers on petroleum applications and mining and metals application which were appropriate for the region.

INSPECTION TRIPS

During the week inspection trips were taken to the British Columbia Research Laboratory and the new Van de Graaf generator recently installed at the University of British Columbia. Other trips were arranged to the Oak Ridge Transit Center, Canadian Western Lumber Company, the Dal Grauer Substation with its modern exterior design with glass front enabling passers-by to see the interior. Also a boat trip on Howe Sound to see a large copper mill and pulp mill, and a trip to the new Wahleach Generating Station were arranged for the members.

SOCIAL ACTIVITIES

On Tuesday evening, a dinner and dance took place with entertainment consisting of songs and dances from "Show Boat." Preceding the dinner, there was a cocktail hour in honor of President Robertson. On Thursday evening there was a banquet preceded by a cocktail hour at which the golf prizes were awarded. Entertainment was provided featuring the cast of the "Theatre Under the Stars." During the days, the ladies were kept busy with a program arranged by the Vancouver ladies under the chairmanship of Mrs. J. H. Steede. There was a daily get-acquainted coffee hour, teas, and a sight-seeing tour of the city including a visit to the Royal Vancouver Yacht Club.

GOLF TOURNAMENT

The golf tournament for the Fisken Trophy was played at the Quilchena Golf Club. The first low net and winner of the J. B. Fisken Trophy was R. M. Lemman, Seattle, Wash.; the second low net winner was J. E. Underhill, Vancouver; and third prize was won by N. S. Clark, Vancouver. The first low gross prize winner was Orman Kent, Vancouver; the runner-up was H. L. Hussey, San Francisco, Calif.; and the third prize was won by E. W. Rockwell, Los Angeles, Calif.

COMMITTEES

Members of the General Committee were J. H. Steede, chairman; L. B. Stacey, vice-chairman; H. O. Bulmer, secretary; W. J. Lind, treasurer. Members-at-large were F. J. Bartholomew, T. C. Clarke, J. B. Hedley, E. W. Johnson, H. J. McLeod, and R. J. Mitchell. Chairmen of working committees were F. O. Wollaston, technical program; C. E. Woolgar, entertainment; E. Wolstencroft, registration; T. H. Crosby, inspection trips; D. S. Smith, hotels; J. T. Turner, transportation; F. D. Bolton, publicity; S. C. Morgan, students; and Mrs. J. H. Steede, ladies.

Air-Moving Equipment Will Be Subject of Fort Wayne Meeting

A special 2-day conference on the application of motors to air-moving equipment and a 1-day symposium on induction motors is planned for Fort Wayne, Ind., October 6–8, 1953, at the Van Orman Hotel.

Sponsored by the Committee on Rotating Machinery and the AIEE Fort Wayne Section, 22 papers covering induction motor design and application problems in various equipment, such as room air conditioners, furnace fans, ventilating fans and blowers, and evaporative coolers, will be read. Special Underwriters' and Armed Forces requirements for fan classifications, and designs for fans cooling military electronic tubes, cabinets, vehicle cabs, and defrosting and ventilating equipment will be considered. The Induction Motor Symposium will deal with design, calculation, and analysis problems.

Tentative Technical Program

Tuesday, October 6

9:00 a.m. Registration

1:30 p.m. First Session

M. L. Schmidt, presiding (General Electric Company)

Welcome: M. L. Miller, chairman, Fort Wayne Section

Fan Motor Characteristics and Standards. *T. E. M. Carville*, Westinghouse Electric Corporation

Automatic Temperature Control of Heating, Ventilating, and Air-Conditioning Air-Handling Systems. *G. W. Steffens*, Minneapolis-Honeywell Regulator Company

The Application of Shaded-Pole Motors to Room Air Conditioners. *R. W. Morgan*, Fedders-Quigan Corporation

Evaporative Coolers and the Motors Used Thereon. *R. J. Peterson*, Utility Appliance Corporation

Ventilation for Farm Buildings. *A. E. Waterman*, James Manufacturing Company

Wednesday, October 7

9:00 a.m. Second Session

R. F. Munier, presiding (Emerson Electric Company)

Armed Service Fan Applications. *C. W. McDowell*, American Blower Corporation

Requirements of Air-Conditioning Fan Motors. *M. D. Irwin*, Carrier Corporation

Underwriters Requirements for Fans. *W. H. Farrell*, Underwriters' Laboratories

Room Air Conditioners. *W. P. King*, Servel, Inc.

Selection and Application of Industrial Fans. *H. D. Diffenbaugh*, American Blower Corporation

12:30 p.m. Luncheon

2:00 p.m. Third Session

E. P. Codling, presiding (Jack and Heintz, Inc.)

Attic Fans and Window Ventilators. *W. H. Wentling*, The Lau Blower Corporation

Development and Application of Furnace Fans. *W. A. Rockafield*, The Brundage Company

Automatic Protection of Motors in Air-Moving Equipment. *W. S. Hirshberg, Jr.*, Spencer Thermostat Division

Unit Heater Fans. *A. Currie*, L. J. Wing Manufacturing Company

Symposium on Induction Motors

Thursday, October 8

9:00 a.m. Fourth Session

S. F. Henderson, presiding (Westinghouse Electric Corporation)

The Magnetic Noise of Polyphase Induction Motors. *P. L. Alger*, General Electric Company

Accuracy and Simplicity in Induction-Motor Calculations. *J. F. H. Douglas*, Marquette University

A Slot Combination Chart for Induction Motors. *J. E. Williams*, University of Illinois

Traveling-Wave Analysis of Distributed Circuits as Applied to Rotating Machinery. *D. S. Dabb*, University of Illinois

12:30 p.m. Luncheon

2:00 p.m. Fifth Session

S. F. Henderson, presiding (Westinghouse Electric Corporation)

Determination of Core Loss in Polyphase Induction Motors. *F. A. List*, Westinghouse Electric Corporation

The Effect of D and L Upon Induction-Motor Design. *R. F. Woll*, Westinghouse Electric Corporation

Volume Coefficient for the National Electrical Manufacturers Association Rerated Motors. *K. M. Chirgwin*, Imperial Electric Company

Induction-Motor Letter Symbols for Use in Technical Papers. *S. F. Henderson*, Westinghouse Electric Corporation

Sixth Annual Machine Tool Conference Will Be Held in Cleveland, October 14–16

The sixth annual AIEE Conference on Machine Tools, sponsored by the AIEE Subcommittee on Machine Tools, will be held at the Cleveland Hotel, Cleveland, Ohio, October 14–16, 1953. A large attendance is expected, composed primarily of electrical and mechanical engineers of the machine tool builders, electrical manufacturers, and users of machine tools such as the automotive and aircraft industries. The conference is an activity of the subcommittee to promote its purpose of "achieving greater productivity and safety of machine tools through electrification, for the purpose of raising the standard of living and aiding the common defense."

The technical program will present a series of 11 papers on a wide variety of subjects, and will provide the engineers with up-to-date information on new products, processes, and techniques. They also will have an opportunity to discuss their applications, and mutual problems in connection with various standards, codes, and safety regulations applicable to the designing, building, and use of electrified machines.

F. S. Blackall, Jr., president of The American Society of Mechanical Engineers, will be the featured speaker at the banquet on October 14. His subject will be "The Engineer's Obligation to a Free Society." "America's 20th Century Future" will be discussed by L. B. Seltzer, editor of *The Cleveland Press*. He will speak at the informal luncheon on October 15.

INSPECTION TRIPS

Several inspection trips have been planned in conjunction with the Machine Tool Conference. With the exception of the Ford Motor Company trip on Thursday morning, they all are scheduled for Friday afternoon, October 16.

The Ford Motor Company, Cleveland Engine Plant. Outstanding among the plants established in Cleveland during the last few years is the Ford Motor Company Engine and Foundry Plant. In the plants the visitors will see the very latest in automatic foundry techniques, and the "automation" of the machining and assembling of the Ford 6-cylinder engine. Included in the tour will be the automatic conveyor line to the test cells involving many miles of wire and more than 2,000 limit switches for the automatic transportation of the engines to and from the test cells.

Chevrolet-Cleveland Division, General Motors Corporation. This plant manufactures and assembles Power Glide transmissions for the Chevrolet, along with other automotive parts. The installations in this plant cover most of the range of machine tools from turning equipment to punch presses and are modern examples of mass production techniques.

Reliance Electric and Engineering Company (*Euclid Plant*). Visitors will be shown the manufacture of control and electronic panels for the complete line of Reliance V*S drives from 1 to 300 horsepower. Complete wiring, assembly, and test of drives from 1 to 30 horsepower will be seen. In addition to manufacturing facilities, the Euclid Plant is the site of the design engineering department. Of considerable interest are the flexible, "cubical" engineering department layout, the template drafting process, digital computers for solution of complex systems, and electronic, motor, and control laboratories.

The Warner and Swasey Company. This company has specialized in building high-precision machine tools, and in recent years has expanded into textile machinery and earth-moving equipment. Visitors will see the manufacture and testing of various types of turret lathes, multiple- and single-spindle automatics, and precision tappers in the machine tool division, and a revolutionary new weaving machine and other textile machines. The tour also will include the Electrical Assembly Department where complicated control panels are assembled and tested.

COMMITTEES

The AIEE Subcommittee on Machine Tools is composed of electrical engineers representing the major machine tool builders, electrical manufacturers, and users of the country. R. H. Clark, Warner and Swasey Company, is general chairman; Kurt Tech, Cross Company, is vice-chairman; and V. R. Murphy, Reliance Electric and Engineering Company, is program chairman.

The Committees for Local Arrangements include the following: R. H. Clark, general chairman; J. C. Ponstingl, assistant chairman; V. R. Murphy, program; H. C. Martin, registration; G. R. Schofield, facilities; J. L. Fuller, budget and finance; J. T. Temin, publicity; K. F. Culler, inspection trips; C. A. Koch, transportation; R. S. Gardner, AIEE Headquarters.

Tentative Technical Program

Wednesday, October 14

8:30–10:30 a.m. Registration

10:30 a.m. Morning Session

J. I. Ehrhardt, presiding (Excello Corporation)

Specific Applications of Electronic Drives to Machine Tools. *F. E. McLane*, Westinghouse Electric Corporation

1:30 p.m. Afternoon Session

A. L. Krause, presiding (Brown and Sharp Company)

Automatic Machine Control. *P. L. Nies*, Ultrasonic Corporation

Some Bases and Interpretations of the National Electric Code as Applied to the Electrification of Machinery. *N. F. Diederich*, Clark Controller Company

Today's Machine Tools Need Modern Electrical Codes. *E. J. Loeffler*, Warner and Swasey Company

Discussion and question period for all papers

7:00 p.m. Banquet

Speaker: F. S. Blackall, president, American Society of Mechanical Engineers, and president, Taft-Pierce Manufacturing Company

Thursday, October, 15

8:30 a.m. Inspection Trip

Ford Motor Company, Cleveland Engine Plant

12:30 p.m. Informal Luncheon

Speaker: L. B. Seltzer, editor, *The Cleveland Press*

2:00 p.m. Afternoon Session

W. P. Curtis, presiding (Ford Motor Company)

The Aircraft Industry and Machine Tools. *W. L. Davis*, Douglas Aircraft Company

Economics of Location of Control Devices on Machine Tools. *W. H. Compton*, Wood-Compton Company; *Dickey Dyer*, The Work-Factor Company

Practical Considerations in the Use of Tracer Controls. *G. L. Rogers*, *J. L. Dutcher*, General Electric Company

Discussion and question period for all papers

Friday, October 16

9:00 a.m. Morning Session

J. P. Madden, presiding (G. A. Gray Company)

Clutches for Machine Tools. *Á. F. Gagne, Jr.*, Consulting Engineer

Dynamic Brake Motor. *Samuel Noodleman*, Standard Dayton Corporation

Panel Discussion: Remarks on the Rerating of Electric Motors. Presented by C. O. Hedges, chairman, and representatives of the Motor and Generator Section of National Electrical Manufacturers Association

Discussion and question period for all papers

12:45 p.m. Inspection Trip

Chevrolet-Cleveland Division, General Motors Corporation

1:15 p.m. Inspection Trip

Reliance Electric and Engineering Company

1:30 p.m. Inspection Trip

Warner and Swasey Company

AIEE Officers to Be Nominated for 1954 Election

For the nomination of officers to be voted upon in the spring of 1954, the AIEE Nominating Committee will meet in New York, N. Y., in January 1954. The officers to be elected are: a president, a treasurer, three directors, and five vice-presidents, one from each of the odd-numbered geographical Districts. Fellows only are eligible for the office of president; Members and Fellows for the offices of vice-president, directors, and treasurer.

To guide this committee in performing its constituted task, suggestions from the membership are, of course, highly desirable. To be available for consideration of the committee, all suggestions must be received by the secretary of the committee at Institute headquarters not later than December 15, 1953.

In accordance with the provisions in the constitution and bylaws, quoted in the following paragraphs, actions relating to the organization of the Nominating Committee are now under way.

Constitution

29. There shall be constituted each year a Nominating Committee consisting of one representative of each geographical District, elected by its executive committee,

one representative of each technical division elected by the division committee, and other members chosen by and from the Board of Directors not exceeding in number the number of technical divisions; all to be selected when and as provided in the Bylaws. The Secretary of the Institute shall be the secretary of the Nominating Committee, without voting power.

30. The executive committee of each geographical District shall act as a nominating committee of the candidate for election as vice-president of that District, or for filling a vacancy in such office for an unexpired term, whenever a vacancy occurs.

31. The Nominating Committee shall receive such suggestions and proposals as any member or group of members may desire to offer, such suggestions being sent to the secretary of the committee.

The Nominating Committee shall name, on or before January 31 of each year, one or more candidates for president, treasurer, and the proper number of directors, and shall include in its ticket such candidates for vice-presidents as have been named by the nominating committees of the respective geographical Districts, if received by the Nominating Committee when and as provided in the Bylaws; otherwise the Nominating Committee shall nominate one or more candidates for vice-president(s) from the District(s) concerned.

Bylaws

Sec. 23. During September of each year, the Secretary of the Nominating Committee shall notify the chairman of the executive committee of each geographical District that by December 15 of that year the executive committee of each District must select a member of that District to serve as a member of the Nominating Committee and shall, by December 15, notify the secretary of the Nominating Committee of the name of the member selected.

During September of each year, the secretary of the Nominating Committee shall notify the chairman of the executive committee of each geographical District in which there is or will be during the year a vacancy in the office of vice-president that by December fifteenth of that year a nomination for a vice-president from that District, made by the District executive committee, must be in the hands of the secretary of the Nominating Committee.

Between October first and December fifteenth of each year, the Board of Directors shall choose five of its members to serve on the Nominating Committee and shall notify the secretary of that committee of the names so selected and shall also notify the five members selected.

The secretary of the Nominating Committee shall give the fifteen members so selected not less than ten days' notice of the first meeting of the committee, which shall be held not later than January thirty-first. At this meeting, the committee shall elect a chairman and shall proceed to make up a ticket of nominees for the offices to be filled at the next election. To insure that full consideration be given to all suggestions from the general membership, they must be in the hands of the secretary of the committee by December fifteenth. The nominations as made by the Nominating Committee shall be published in the March issue of *Electrical Engineering*, or otherwise mailed to the Institute membership not later than the first week in March.

Independent nominations may be made in accordance with provisions in article VI, section 32, of the constitution and section 24 of the bylaws, which are quoted in the following:

Constitution

32. Independent nominations may be made by a petition of twenty-five (25) or more corporate members sent to the secretary when and as provided in the bylaws; such petitions for the nomination of vice-presidents shall be signed only by members within the District concerned.

Bylaws

Sec. 24. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with article VI, section 32 (Constitution), must be received by the secretary of the Nominating Committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the Nominating Committee in accordance with article VI of the Constitution and sent by the secretary to all qualified voters on or before April 15 of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

(*Signed*) H. H. Henline
Secretary

Joint Computer Conference Will Be Cosponsored by AIEE

"Information Processing Systems—Reliability and Requirements," is the theme of the Joint AIEE–Institute of Radio Engineers–Association for Computing Machinery Computer Conference and Exhibition to be held at the Statler Hotel, Washington, D. C., December 8–10, 1953.

The program includes papers describing the reliability of existing large-scale electronic digital computing machines as well as other papers describing reliability requirements for certain necessary applications in the fields of government, business, and industry. Inspection trips will permit actual demonstrations of the topics under discussion. A large exhibit area will bring together the products of more manufacturers for this conference than ever has been possible heretofore.

Preliminary programs and reservation applications will be mailed to members of the sponsoring organizations. Others may request this information by writing L. R. Johnson, Registration Committee Chairman, 2018 Sycamore Drive, Falls Church, Va.

Textile Industry Conference to Be Held in Raleigh, N. C.

Sponsored by the Subcommittee on Textile Industry of the AIEE Committee on General Industry Applications, a Textile Industry Conference on Electric Equipment will be held in Raleigh, N. C., October 29–30, 1953. A tentative technical program for the meeting has been announced as follows:

Thursday, October 29

11:00 a.m.–1:30 p.m. Registration

Lobby, Riddick Laboratories Auditorium, campus of North Carolina State College

1:30 p.m. Afternoon Session

Swaffield Cowan, chairman of Subcommittee on Textile Industry, presiding (Factory Insurance Association, Charlotte, N. C.)

Address of Welcome. Speaker to be announced

Ungrounded Power Systems in Textile Mills. *H. C. Swannell*, J. E. Sirrine Company, Greenville, S. C.

Grounded Power Systems in Textile Mills. *H. B. Greear*, General Electric Company, Atlanta, Ga.

Variable-Speed Drive With Magnetic Amplifier Control. *G. A. Bauman*, Century Electric Company, St. Louis, Mo.; *C. C. Gould*, Square D Company, Milwaukee, Wis.

6:00 p.m. Social Hour

Tarheel Club

7:00 p.m. Barbecue Dinner

Tarheel Club

Friday, October 30

9:00 a.m. Registration

9:30 a.m. Morning Session

V. P. Sepavich, secretary of Subcommittee on Textile Industry, presiding (Crompton and Knowles Loom Works, Worcester, Mass.)

Overload Protection for Electric Motors. *M. R. Brice*, Cutler-Hammer, Inc., Milwaukee, Wis.

High-Interrupting-Capacity Fuses. *J. C. Lebens*, Bussman Manufacturing Company, St. Louis, Mo.

Circuit Breakers as Applied to Textile Mills. *W. M. Emmons*, Westinghouse Electric Corporation, Atlanta, Ga.

12:30 p.m. Luncheon

Speaker: H. B. Robinson, Carolina Power and Light Company, Raleigh, N. C.

2:00 p.m. Afternoon Session

Dan McConnell, presiding (Cone Mills Corporation, Greensboro, N. C.)

A Progress Report on Development and Standardization of Textile Mill Control Enclosures. *Swaffield Cowan*, Factory Insurance Association, Charlotte, N. C.

The National Electrical Manufacturers Association Motor Rerating Program. *W. H. Formhals*, Westinghouse Electric Corporation, Buffalo, N. Y.

Panel Discussion—Electrical Problems and Remedies
Moderator: Dan McConnell

Panel: M. R. Brice; G. A. Bauman; C. C. Gould; W. M. Emmons; L. E. Edwards; W. H. Formhals; G. G. Mattison, Duke Power Company; W. W. Hanks, Southern Electric Service Company; J. E. Jenkins, Armature Winding Company

Scintillation Counters to Be Conference Subject

According to a recent announcement, a Conference on Scintillation Counters will be held in Washington, D. C., January 26–27, 1954. Chairman pro tem of the Conference Committee is G. A. Morton. Chairmen of the Committees on Local Arrangements and Publicity and Attendance are, respectively, L. Costrell and R. W. Johnston.

As tentatively planned, there will be four sessions covering the following topics:

1. Scintillation Counter Spectrometry
2. Cosmic Ray and High-Energy Particle Measurements With Scintillation Counters
3. General Applications
   (*a*). Tracer
   (*b*). Prospecting
   (*c*). Medical and Health Protection
   (*d*). Analytical Problems, including Speed Coincidence, and so forth
4. Multipliers and Phosphors
   (*a*). New Multipliers
   (*b*). Multiplier Performance
   (*c*). Multiplier Needs
   (*d*). Phosphors

Committee Is Appointed for Winter General Meeting

The following have been appointed by President Elgin B. Robertson as members of a general committee to make plans for the Winter General Meeting to be held in the Hotel Statler, New York, N. Y., January 18–22, 1954: C. T. Hatcher, chairman; A. J. Cooper, vice-chairman; J. J. Anderson, secretary; C. S. Purnell, budget coordinator; M. D. Hooven, Vice-President, District 3, 1953–54; L. F. Hickernell, technical program (chairman, Committee on Technical Operations); R. T. Ferris, publicity (chairman, Committee on Public Relations); L. F. Stone, general session (chairman, New York Section).

First Prize Papers Announced for Student Branch Contest

District Branch First Prize winners for 1952–53 were introduced during the recent Summer General Meeting in Atlantic City, N. J. The following is a list of the prize-winning papers:

District 1. "An Experimental Determination of Multiple Time Constants," by Theron Usher, Jr., Yale University

District 2. "The Linear Variable Differential Transformer," by Louis A. DiPaolo, Alan J. Kane, and Charles A. Quinn, Villanova College

District 3. "The Transient Response of the Saturable Reactor as Applied to Industrial Waste Precipitation," by Richard Farrelly, Manhattan College

District 4. "Problems in Crystal Manufacturing," by Hannis W. Thompson, Jr., and Stephen H. Wesley, Jr., North Carolina State College

District 5. "Cold-Cathode Trigger Tube as a Sensitive Relay," by Rodney D. Driver, University of Minnesota

District 6. "Electronic Analogue Computer," by R. L. Richardson, Syracuse University

District 7. "A Method Measuring the Electron Density of the Ionosphere," by Harry W. Rose, New Mexico College of Agriculture and Mechanical Arts

District 9. "Neon Brilliance Control System," by Dayne Hansen, University of Washington

In accordance with the custom of introducing District Branch First Prize winners at the Summer Meetings of the Institute, winners of the 1953–54 competition will attend the 1954 Summer and Pacific General Meeting in Los Angeles, Calif., June 21–25.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Radio Communications Systems (*A. C. Dickieson, Chairman; E. D. Becken, Vice-Chairman; R. D. Campbell, Secretary*). The attention of the committee has been directed particularly to the very large use of radio by the petroleum, pipeline, railroad, and power industries. Consideration is being given accordingly to the scope and method of presentation of information on this subject including radio system planning and operation, conservation of the frequency spectrum, problems related to congestion of radio relay routes converging in cities, the interconnection of point-to-point and mobile systems, and related matters. A series of technical papers bearing on these matters is included in the program for the Fall General Meeting in Kansas City. A luncheon meeting of the committee is planned at Kansas City on Wednesday, November 4, 1953.

General Applications Division

Committee on Air Transportation (*W. L. Berry, Chairman; L. R. Larson, Vice-Chairman; Peter Duyan, Jr., Secretary*). A new Subcommittee on Dielectric Testing Procedures for Aircraft Electric Equipment and Insulation Materials has been set up for the purpose of formulating test codes for aircraft electrical insulation materials. Members of the subcommittee are J. P. Dallas, chairman; D. W. Exner, Fred Foulon, C. F. McMeekin, H. S. Gillespie, W. B. Penn, and C. S. Milliken.

Many in the aircraft industry believe that inadequate or deteriorated insulation is the cause of a large portion of aircraft electrical failures, but is seldom recognized as such. Electrical failure is usually a progressive reaction that proceeds from a small breakdown, often remote from the final spectacular display of smoke, fire, and molten metal. The aircraft operating and maintenance personnel do not have the facilities to seek out the basic cause of these failures. For this reason the importance of better insulation practices is often overlooked in the problem of improving aircraft reliability.

It is the intent of the subcommittee to make a study of experiences with insulation materials throughout the world, to investigate problems arising from the severe environmental conditions in aircraft, and to recommend test procedures that will insure proper performance of insulation.

Committee on the Production and Application of Light (*R. L. Oetting, Chairman; J. F. Dickerhoff, Vice-Chairman; J. F. Angier, Secretary*). At the 1954 Winter General Meeting, a program on lighting maintenance is scheduled and this will be considered from several viewpoints: the consumer's, the lamp designer's, and that of the fixture manufacturer. Both indoor and outdoor lighting and both sides of a maintenance program will be discussed: (1) how often? (2) how to?

The committee met during the 1953 Winter and Summer General Meetings and will meet again in New York in January. Members interested in fields of producing and applying light and associated forms of radiant energy are invited to participate in person or by correspondence.

Power Division

Committee on Relays (*W. E. Marter, Chairman; Frank von Roeschlaub, Vice-Chairman; L. L. Fountain, Secretary*). A new working group has been set up to study the relaying aspects of automatic load dropping when system load exceeds the connected capacity. This condition can occur due to loss of tie-line capacity or generation or to a sudden unexpected increase in system load. There is considerable interest in methods of automatically dropping load under these conditions to prevent the occurrence of a major system outage. This subject also is being studied by a group sponsored by the Committee on System Engineering, but this study will cover the system aspect of the problem and the work of the two groups will be co-ordinated so that no duplication of effort will occur.

Committee on Rotating Machinery (*E. I. Pollard, Chairman; M. L. Schmidt, Vice-Chairman; R. F. Edwards, Secretary*). The Subcommittee on Insulation has completed a Proposed Test Code for Evaluation of Systems of Insulating Materials for Random Wound Electric Machinery. A letter ballot in the Committee on Rotating Machinery is in process. Several manufacturers are co-operating with the subcommittee in an extensive test program to provide data which it is hoped will show the necessary co-ordination between the accelerated tests outlined in the test code and life experience on actual machines.

A working group of the Subcommittee on Induction Machinery is reviewing Test Code *500* to consider objections received from the American Standards Association Standards Committee. A working group of the Subcommittee on Single-Phase and Fractional-Horsepower Motors is ready to revise Test Code *502* as soon as the format of Number *500* is approved as a model.

A new Subcommittee on Publicity and Bibliography has been formed to revise and bring up to date the Bibliography of Rotating Electric Machinery.

Science and Electronics Division

Committee on Instruments and Measurements (*J. G. Reid, Jr., Chairman; Ernst Weber, Vice-Chairman (East); W. S. Pritchett, Vice-Chairman (West); C. F. Savage, Jr., Secretary*). Standard Number *4*, "Measurement of Voltage in Dielectric Tests," is now in trial use and appears to be receiving rather general acceptance. The subcommittee responsible for the revision of this Standard reports that it probably will receive formal and final approval in the very near future.

The Subcommittee on Varmeter Markings submitted a report which was printed in *Electrical Engineering* (*Nov '50, pp 1007–08*). A rather wide divergence of practice was reported so that, although a standard for such markings might be desirable, and the committee made a recommendation for use of "IN" and "OUT" as the standard marking, little comment and discussion have appeared, indicating a continued divergence of opinion and but little interest in a formal standard. In view of this situation, the committee under A. B. Craig, recently in a stand-by status, has been discharged.

Committee on Magnetic Amplifiers (*E. V. Weir, Chairman; W. J. Dornhoefer, Vice-Chairman; H. W. Lord, Secretary*). The Subcommittee on Definitions of the Committee on Magnetic Amplifiers met during the AIEE Summer General Meeting at Atlantic City, N. J., with W. J. Dornhoefer, chairman of the subcommittee, presiding.

A glossary of 108 magnetic amplifier terms was reviewed. Each of the 12 mem-

bers present was assigned a portion of this list and asked to write definitions of the assigned terms. A meeting of this subcommittee was held in New York, N. Y., to review these definitions before submitting them to the full Magnetic Amplifier Committee for review.

A working group was established to make a set of initial recommendations with respect to graphical symbols and terminal markings for magnetic amplifiers. This working group met in New York in order to prepare its report for presentation to the Definitions Subcommittee.

AIEE PERSONALITIES.....

W. L. Everitt (AM '25, F '36), dean, College of Engineering, University of Illinois, Urbana, has been named the recipient of the Institute of Radio Engineers' Medal of Honor for 1954. Dr. Everitt received the award "for his distinguished career as author, educator, and scientist; for his contributions in establishing electronics and communications as a major branch of electrical engineering; for his unselfish service to his country; for his leadership in the affairs of the Institute of Radio Engineers." Dr. Everitt has had a distinguished career as engineer, educator, consultant, and author of textbooks and scientific articles in the radio field. He held teaching posts at Cornell University, Ithaca, N. Y.; University of Michigan, Ann Arbor; and Ohio State University, Columbus, before coming to the University of Illinois in 1945 as head of the department of electrical engineering. He was appointed dean of the College of Engineering in 1949. In 1940 Dr. Everitt became a member of the Communications Section of the National Defense Research Committee and during World War II served as director of Operational Research in the office of the Chief Signal Officer. In 1950 he served as a member of the Senate Advisory Committee on Color Television. Dr. Everitt is a director and past president of the Institute of Radio Engineers and has served as a director of the AIEE (1947–51) and on the following Institute committees: Communication (1932–42, Chairman, 1937–39); Technical Program (1937–39); Education (1944–50); Edison Medal (1947–51); Research (1947–51); Board of Directors (1947–51); Executive (1949–51); Volta Scholarship Trustee (1949–51); and Commission of Washington Award (1951–53).

J. W. McRae (AM '37, M '50), vice-president, Bell Telephone Laboratories, New York, N. Y., has been elected vice-president of the Western Electric Company and will succeed D. A. Quarles as president of the Sandia Corporation, Albuquerque, N. Mex. Dr. McRae has been associated with the Laboratories since 1937. He is a native of Vancouver, British Columbia, Canada. He received his bachelors degree in electrical engineering from the University of British Columbia in 1933, and his masters degree in 1934. He earned his doctorate from California Institute of Technology in 1937. His early work at Bell Laboratories included research on transoceanic radio transmitters and microwave techniques. In 1942 he was commissioned a major in the United States Army Signal Corps and co-ordinated development programs for air-borne radar equipment and radar countermeasure devices, receiving the Legion of Merit for this work. He was later chief of the engineering staff of the Signal Corps Engineering Laboratories, Bradley Beach, N. J., and subsequently became deputy director of the engineering division with the rank of colonel. He returned to Bell Laboratories in 1946 as director of radio projects and television research. He was appointed director of electronic and television research in 1947, and in 1949 was appointed director of apparatus development, subsequently becoming director of transmission development. He has been a vice-president since 1951. Dr. McRae is serving as president of the Institute of Radio Engineers and is a member of Sigma Xi.

W. L. Everitt

J. W. McRae

W. J. Lyman (AM '25, F '43), manager, Planning and Development Department, Duquesne Light Company, Pittsburgh, Pa., and **C. T. Sinclair** (AM '19, F '36), chief engineer, Duquesne Light Company, have been elected vice-presidents of the company. Mr. Lyman will be in direct charge of and responsible for all activities of the Operating Division, and Mr. Sinclair will be in charge of and responsible for all activities of the Engineering and Construction Division. Mr. Lyman is a native of Cambridge, Mass., and graduated from Carnegie Institute of Technology in 1924 with a bachelor of science degree in electrical engineering and in 1930 received a professional degree in electrical engineering from the same institution. Joining Duquesne Light Company in 1924 as an apprentice engineer, Mr. Lyman has served as a junior engineer and assistant field engineer, and as section engineer and manager. He is a member of the Pennsylvania Electric Association and the Association of Edison Illuminating Companies. He has served on the AIEE Committees on Membership (1941–47) and Power Generation (1948–49). Mr. Sinclair is a native of Baltimore, Md., and graduated from Lehigh University in 1917 with an electrical engineering degree. He joined Duquesne Light Company in 1925 as supervisor of transmission and distribution engineering. He was appointed chief engineer in charge of engineering and construction in 1947. Mr. Sinclair is a member of the Pennsylvania Electric Association, American Standards Association, Edison Electric Institute, and Association of Edison Illuminating Companies. Mr. Sinclair served as vice-president, District 2, of the Institute from 1939–41, and on the following committees: Transmission and Distribution (1929–42, Chairman, 1935–37); Technical Program (1935–37); Standards (1936–50); and Constitution and Bylaws (1945–46).

N. C. Pearcy (AM '24, F '43), chief electrical engineer, Pioneer Service and Engineering Company, Chicago, Ill., has been named chief engineer, and **H. L. Hoeppner** (AM '18, F '43), senior electrical engineer, has become chief electrical engineer. **E. D. Uhlendorf** (AM '13, M '44, Member for Life), senior vice-president, has become vice-president and consultant. Mr. Pearcy was graduated from Purdue University in 1922 with a bachelors degree in electrical engineering. He was employed by Louisville (Ky.) Gas and Electric Company from 1924 to 1929, at which time he joined the staff of Pioneer with which he has been associated since, except for a short period with Carnegie Illinois Steel Corporation. Mr. Pearcy is a Director of the Institute and has served as secretary, District 5 (1945–46), and on the Committee on Automatic Stations (1937–38). Mr. Hoeppner received a bachelors degree in electrical engineering from Tri-State College in 1917 and has done postgraduate work at Northwestern University and Illinois Institute of Technology. After a period with General Electric Company and other employers he joined Pioneer in 1922 and has continued in its employ. He is a member of the Western Society of Engineers and has served on the AIEE Committee on Power Generation (1939–40).

Frederick Krug (AM '17, F '36, Member for Life), vice-president, International Power Company, Ltd., Montreal, Quebec, Canada, has been named president of the company. Mr. Krug has been associated with the company or its subsidiaries for more than 30 years. Before joining the Puerto Rico subsidiary in 1922, Mr. Krug served as engineer with the Rosario Mine in Honduras. Since 1937 he has devoted his time to the management of the electrical utility subsidiaries in Mexico, El Salvador, Venezuela, Bolivia, and British Guiana, and to the Montreal Engineering Company, of which he is general manager. He was educated at Cooper

Union and the New Mexico Institute of Mining and Technology. He is a member of the Engineering Institute of Canada and has served on the AIEE Committees on Membership (1943–45) and Sections (1943–46).

W. A. Mosteller (M '46), product manager, General Electric Company, Detroit, Mich., has been appointed sales manager for the Michigan District. A 1923 graduate of Texas Agricultural and Mechanical College with a bachelor of science degree in electrical engineering, he joined General Electric that same year as a test engineer in Schenectady, N. Y. He then served 2 years in the Motor and Generator Department and 2 more years in the Industrial Engineering Department. In 1929 he was transferred to the Chicago (Ill.) office as a field engineer and remained there until 1931 when he came to the Detroit office as an application engineer. Mr. Mosteller is a registered professional engineer in Michigan and a member of the Association of Iron and Steel Engineers and the Engineering Society of Detroit. He has served on the AIEE Committee on Industrial Power Systems (1947–52).

L. V. Bewley (AM '27, F '47), head, Department of Electrical Engineering, Lehigh University, Bethlehem, Pa., has been awarded the R. R. and E. C. Hillman award of $1,000 given annually "to a member of the faculty who is deemed to have done most toward advancing the interests of the university." Professor Bewley is a graduate of the University of Washington and received his masters degree from Union College. He joined the Lehigh faculty in 1940 after 17 years of service with the General Electric Company. During World War II he served as an artillery officer and staff officer with the rank of colonel. Professor Bewley is a member of the American Society for Engineering Education, Sigma Xi, and Tau Beta Pi. He has served on the following AIEE committees: Basic Sciences (1940–41, 1949–52); Education (1941–42); and Board of Examiners (1952–53).

G. V. Lago (AM '47, M '52), assistant professor of electrical engineering, University of Missouri, Columbia, has been awarded an RCA Predoctoral Fellowship in Electronics for the academic year 1953–54. Mr. Lago received his bachelor of science degree in engineering physics from the University of Oklahoma in 1940. He received his master of science degree in engineering from Purdue University in 1949. From 1941 to 1947 Mr. Lago was a member of the technical staff of the Bell Telephone Laboratories, New York, N. Y., and since that time has been assistant professor of electrical engineering at the University of Missouri. He plans to devote his year of research to a stability study of feedback systems that contain a time-delay element. He will attend Purdue University. Mr. Lago is a member of Tau Beta Pi, Sigma Tau, Pi Mu Epsilon, and Eta Kappa Nu.

W. L. Winter (AM '21, M '43), assistant to the manager, electric utility department, Pacific Coast District, Westinghouse Electric Corporation, San Francisco, Calif., has been appointed distribution apparatus manager for the district. Following his graduation from the University of California with an electrical engineering degree, Mr. Winter joined Westinghouse in East Pittsburgh, Pa., in 1916. After serving in World War I, he was assigned to the Westinghouse office in San Francisco, remaining there except for the 1933–42 period when he was in the Salt Lake City (Utah) office. Mr. Winter is past president of the Engineers Club of San Francisco and a member of the San Francisco Electric Club and the Pacific Coast Electrical Association. He is a past chairman of the San Francisco and Utah Sections of the Institute and has served on the Committee on Electrical Machinery (1937–38).

C. B. Carpenter (AM '23, F '44), equipment planning engineer, Pacific Telephone and Telegraph Company, Portland, Oreg., has been named transmission and protection engineer for the Oregon area. Mr. Carpenter started with Portland General Electric in 1923, joined Washington Water Power in 1926, and in 1929 went with Pacific Telephone and Telegraph as an engineer. He served for several years in that capacity before being made assistant chief engineer. Mr. Carpenter is a past chairman of the Portland Section and has served as vice-president, District 9 (1944–46), and on the Institute Committees on Communication (1938–41, 1944–46) and Transfers (1951–52, Chairman, 1951–52).

E. D. Becken (AM '43), assistant to the president, RCA Communications, Inc., New York, N. Y., has been elected assistant vice-president and plant operations engineer. Mr. Becken began his career with RCA as an engineer in Washington, D. C., in 1935. He later held positions in the engineering department at Rocky Point and New York. He has been assistant to the president since November 1953. Mr. Becken has a master of science degree in electrical engineering from the University of Minnesota and a masters degree in business and engineering administration as a Sloan Fellow from the Massachusetts Institute of Technology. Mr. Becken has served on the following AIEE committees: Communication (1947–49) and Radio Communication Systems (1949–51, 1952–53).

H. T. Zamzow (AM '48), manager, capacitor and regulator sales, Line Material Company, Milwaukee, Wis., has been appointed western apparatus manager with headquarters in San Francisco, Calif. After receiving his bachelor of science degree in electrical engineering from the University of Nebraska in 1935, Mr. Zamzow was employed in the utility and consulting engineering fields for 11 years. He joined Kyle Corporation in 1946 and handled Kyle sales promotion in ten western states. When Kyle merged with Line Material in 1948, Mr. Zamzow was appointed apparatus engineer for the Mountain States Division, Portland, Oreg., and held this position until his appointment to manager of capacitor and regulator sales in 1952.

C. L. Brown (AM '48), distribution engineer, Pacific Power and Light Company, Portland, Oreg., has been advanced to chief distribution engineer. Mr. Brown graduated from the University of Idaho in 1927, and was appointed district engineer for Pacific Power and Light upon graduation. He became division engineer in 1937 and distribution engineer in 1943. Mr. Brown is a registered professional engineer in Oregon and has served as chairman of the power and publicity committees of the AIEE Portland Section.

E. I. Shobert, II (AM '51), manager, Research and Engineering, Carbon Division, Stackpole Carbon Company, St. Marys, Pa., has received the American Society for Testing Materials Award of Merit for important contributions to the work of the society. Mr. Shobert received the award for efficient and productive services in committee on electrical heating, resistant, and related alloys, and particularly for notable work on electric contacts and the preparation and publication of a bibliography on electric contacts.

J. W. Hines (AM '48), Mid-West sales manager, Erico Products, Chicago, Ill., has been appointed director of sales, Magnecord, Inc., Chicago. He had been employed previously by Magnecord as a sales engineer. Mr. Hines attended Carnegie Institute of Technology and received his bachelor of science degree in electrical engineering in 1947. After graduation he became chief engineer for radio station *WBVP*, Beaver Falls, Pa. He joined Magnecord originally in 1951 and had been with Erico since May 1952. Mr. Hines is a member of the Institute of Radio Engineers and Eta Kappa Nu.

E. D. T. Norris (AM '24, F '30), chief engineer, Transformer Department, Ferranti, Ltd., Hollinwood, Lancashire, England, has been appointed consulting engineer. Mr. Norris has been with the company since 1920 as chief assistant designer and later chief engineer in the Transformer Department. He was chairman of the Transmission Section of the Institution of Electrical Engineers, Great Britain, and is chairman of the Transformer Committee of the Electrical Research Association and of the Transformer Group of the International Conference on Large Electric High-Tension Systems. He is also a member of numerous committees of the British Standards Institution and the British Electrical and Allied Manufacturers Association.

S. L. M. Barlow (M '51), managing director, Barlow and Young, Ltd., London, England, has been named president of the Electrical Contractors' Association (ECA), Great Britain. Mr. Barlow was born in 1908 at Wallington, Surrey, and was educated at Whitgift School, Croydon, and at London University. He has been managing director of Barlow and Young since 1933. Mr. Barlow joined ECA in 1940 and was vice-chairman of the London branch in 1946 and chairman the following year. He was elected to the ECA Council in 1947 and has served on the

Executive Committee since 1951. He became vice-president of ECA last year.

F. J. Mollerus (M '47), manager, electrical distribution and telephone section, Hanford Engineer Works, General Electric Company, Richland, Wash., has been appointed plant electrical engineer for the manufacturing department of the plutonium manufacturing plant. Mr. Mollerus is a graduate of the University of Wisconsin. He joined General Electric in 1924, working in Schenectady, N. Y., until 1930 when he was assigned to a post in Chile. He came to Hanford in 1946. Mr. Mollerus is serving on the AIEE Committee on Chemical, Electrochemical and Electrothermal Applications (1950–53).

R. D. Teasdale (AM '46), associate professor of electrical engineering, Georgia Institute of Technology, Atlanta, has been appointed assistant to the director of engineering and development, Magnetic Metals Company, Camden, N. J. A native of Mt. Lebanon, Pa., Dr. Teasdale received his bachelors degree from the Carnegie Institute of Technology. He received the masters degree and the doctorate from Illinois Institute of Technology. He was on the Westinghouse Electric Corporation training program and has worked with the General Electric Company and RCA Victor. He is a member of Sigma Xi, Eta Kappa Nu, Tau Beta Pi, Institute of Radio Engineers, and the American Association for the Advancement of Science.

J. S. Thompson (AM '14, F '38, Member for Life), and **A. A. Browne** (AM '38, M '47), president and vice-president and general manager, respectively, Pacific Electric Manufacturing Corporation, San Francisco, Calif., have been named to the board of directors, Federal Electric Products Company, Newark, N. J. Pacific Electric Manufacturing Corporation was acquired recently by Federal Electric. Mr. Thompson and Mr. Browne will continue in their posts at Pacific Electric. Mr. Thompson has served on the AIEE Committee on Public Relations (1952–53).

C. A. Beers (AM '36), assistant supervisor of personnel, Power Transformer Department, General Electric Company, Pittsfield, Mass., has been appointed manager of communications. A native of Cleveland, Ohio, Mr. Beers attended the Case School of Applied Science (now Case Institute of Technology) where he received a bachelor of science degree in electrical engineering. He joined General Electric in 1935 and was assigned on test at Schenectady, N. Y., Erie, Pa., and Pittsfield, Mass. From 1936 to 1939 he served as instructor for the apprentice school at Pittsfield. He was transferred to personnel work in 1946.

R. E. Neidig (AM '38, M '47), assistant chief engineer, Metropolitan Edison Company, Reading, Pa., has become chief engineer. Mr. Neidig started with Metropolitan Edison in 1925, shortly after his graduation from Tri-State College. He successively held positions as relay tester, relay engineer, operating engineer, electrical engineer, division operating superintendent, assistant chief engineer, and now chief engineer. Mr. Neidig has served on the Institute Committees on Carrier Current (1947–49) and Protective Devices (1951–53).

H. M. Rankin (AM '20, F '51), vice-president in charge of engineering and production, Metropolitan Edison Company, Reading, Pa., retired July 1, 1953. Mr. Rankin became associated with Metropolitan Edison in 1926 following 14 years' work in the engineering department of the General Electric Company and a period as operating engineer of the Georgia Railway and Power Company. He successively held positions as supervisor of power supply and chief engineer of Metropolitan Edison and was elected a vice-president in 1950.

D. D. Smalley (AM '20, F '47), vice-president in charge of operations, Pacific Gas and Electric Company, San Francisco, Calif., has been appointed vice-president and assistant general manager. Mr. Smalley has served on the AIEE Committee on Management (1949–52).

J. E. Smet (AM '46), manager, New Haven (Conn.) district office, Allis-Chalmers Manufacturing Company, has been named manager of the Hartford (Conn.) district office. Mr. Smet has been with Allis-Chalmers since 1946 and was a sales representative in the Boston (Mass.) district office before being assigned to New Haven. He is a graduate electrical engineer of the University of New Hampshire.

Jerome Ottmar (AM '49), manager of engineering and sales, General Plate Division, Metals and Controls Corporation, Attleboro, Mass., has been elected a vice-president of the corporation. Mr. Ottmar has been affiliated with Metals and Controls since 1938. He is an engineering graduate of the University of Minnesota and attended the Harvard Business School Advanced Management Class. He was associated with Minneapolis-Honeywell Regulator Company prior to joining Metals and Controls Corporation.

F. I. L. Dyke (AM '53), Margison Babcock and Associates Limited, Toronto, Ontario, Canada, has been named supervisor of the electrical section of the consulting engineering firm. Mr. Dyke is a graduate in electrical engineering from Queen's University and is a member of the Association of Professional Engineers.

T. J. Manning (AM '47), sales engineer, The Okonite Company, Birmingham, Ala., has been appointed district manager of the Cincinnati (Ohio) office of the company. Mr. Manning has been associated with Okonite since 1946. A graduate of Georgia Institute of Technology, he has had previous sales experience with the Birmingham Electric Company (now incorporated in the Alabama Power Company).

J. S. Brown (AM '40), chief engineer, Andrew Corporation, Chicago, Ill., has been named director of engineering. Mr. Brown has been with Andrew for 10 years.

R. C. Disque (M '20, F '50), dean, College of Engineering, Drexel Institute of Technology, Philadelphia, Pa., retired August 31, 1953. Dr. Disque has been named dean emeritus and professor emeritus of electrical engineering. He has been associated with Drexel since 1919 and is one of the country's leading authorities on the application of the Co-operative Plan in higher technical education.

H. A. Anderson (AM '41, M '51), chief incandescent engineer, Duro-Test Corporation, North Bergen, N. J., has been appointed commercial engineer. Mr. Anderson has been with Duro-Test since 1937, except for service in the United States Navy from 1943 to 1946. Mr. Anderson is a member of the Illuminating Engineering Society, International Municipal Signal Association, and the Petroleum Electrical Supply Association.

R. C. Bickel (AM '50), sales engineer, Andrew Corporation, Chicago, Ill., has been named regional sales engineer, with headquarters in Ridgewood, N. J. Mr. Bickel has been with Andrew since 1946.

A. E. Maibauer (AM '31), assistant to the manager, New York Sales Development Group, Bakelite Company, New York, N. Y., has been appointed manager, Wire and Cable Materials Division. Mr. Maibauer joined Bakelite in 1925 following his graduation from Cooper Union.

Leon Podolsky (M '45), technical assistant to the president, Sprague Electric Company, North Adams, Mass., has been appointed chairman of Sectional Committee *C83* of the American Standards Association. The committee will be concerned with standards, specifications, methods of testing, and rating for components used in electronic circuits.

D. C. Ober (AM '16), executive vice-president, The Cleveland (Ohio) Electric Illuminating Company, has been elected senior vice-president. Mr. Ober joined the company in 1912, the year before he was graduated from Case Institute of Technology with the degree of bachelor of science in electrical engineering. He advanced to assistant in charge of the electrical engineering department in 1917, to executive engineer of the company in 1933, to vice-president in 1944, and to executive vice-president in 1945. He is a member of the Cleveland Engineering Society.

K. A. Blind (AM '32, M '39), chief engineer, Dings Magnetic Separator Company, Milwaukee, Wis., has joined the Doerr Electric Corporation, Cedarburg, Wis., as assistant to president. Mr. Blind is a graduate of the Technical University, Stuttgart, Germany.

His experience includes 12 years as design engineer and chief electrical engineer for Harnischfeger Corporation, Milwaukee. **C. F. Kowal** (AM '45, M '51), design engineer, Louis Allis Company, Milwaukee, also has joined Doerr Electric Corporation as assistant sales manager.

V. K. Zworykin (M '22, F '45), vice-president, technical consultant, and director of electronic research, RCA Laboratories Division, Radio Corporation of America, Princeton, N. J.; **E. F. W. Alexanderson** (AM '04, F '20, Member for Life), General Engineering and Consulting Laboratory, General Electric Company, Schenectady, N. Y.; **J. V. L. Hogan** (AM '11, M '20, Member for Life), president, Hogan Laboratories, Inc., New York, N. Y.; and **O. H. Caldwell** (M '42), Caldwell-Clements, Inc., New York, N. Y., were awarded citations by the Radio Pioneers as outstanding living leaders in the radio industry.

D. A. Griffith (AM '39, M '49), assistant manager of the Allis-Chalmers Manufacturing Company, Washington, D. C., district office in charge of federal controls and regulations, has been recalled to the company's Pittsburgh (Pa.) works as assistant general manager. Mr. Griffith became associated with Allis-Chalmers Pittsburgh works in 1927. He was named assistant to the general manager in 1947. During 1951, Mr. Griffith served as chief of transformer section of the National Production Authority's Power Equipment Division.

F. L. Snyder (M '46, F '51,), manager Aviation Gas Turbine Division, Westinghouse Electric Corporation, Sharon, Pa., has been elected a vice-president of the company assigned to the staff of the executive vice-president, Defense Products Divisions. Mr. Snyder was born in Martinsburg, Pa., was graduated from Gettysburg College, did graduate work at Columbia University, and joined Westinghouse as a design engineer at the Transformer Division in 1925. He was named manager of the Aviation Gas Turbine Division in 1951.

R. S. Kersh (AM '42, M '45), executive vice-president, Westinghouse Electric International Company, New York, N. Y., has become vice-president, Westinghouse Electric Corporation, in charge of the Eastern District, with headquarters at New York. Mr. Kersh joined Westinghouse in 1929, the same year he was graduated from Mississippi State College. He served the company in sales assignments in the south, southwest, and Pittsburgh, Pa., before becoming manager of the Steam Division in 1951. A year later he was elected executive vice-president of the Westinghouse Electric International Company.

J. H. Chiles, Jr. (AM '28, F '48), manager of engineering, Transformer Division, Westinghouse Electric Corporation, Sharon, Pa., has been named chairman of the American Standards Association's (ASA) Sectional Committee *C-57* on Transformers, Regulators, and Reactors. Mr. Chiles has been a member of ASA *C-57* for approximately 10 years and has been active in standardization work. He has served on the AIEE Committees on Instruments and Measurements (1949–53) and Transformers (1949–53).

C. E. Ganther (AM '39, M '48), superintendent, Electrical Department, and **A. C. Gohlke** (AM '34, M '50), assistant electrical engineer, The Cleveland (Ohio) Electric Illuminating Company, have been appointed general superintendent of the Electrical Department and director of electrical engineering, respectively. Mr. Ganther has served on the AIEE Committee on Safety (1950–53), and Mr. Gohlke has been on the AIEE Committee on System Engineering (1948–49).

H. E. Jensen (M '41), chief engineer, C and D Batteries, Inc., Conshohocken, Pa., has been appointed vice-president in charge of engineering. Mr. Jensen joined the engineering staff of C and D Batteries as a research and development engineer in 1950. In October 1951, he became chief engineer. Mr. Jensen is an electrical engineering graduate of Drexel Institute of Technology.

R. O. Bradley (AM '51), assistant to the director of engineering, Toledo (Ohio) Scale Company, has been appointed director of engineering. Mr. Bradley joined Toledo Scale Company in 1937, and was advanced to junior engineer in 1940. In 1947 he became senior engineer and in 1951 was appointed assistant to the director of engineering.

D. D. Mallory (AM '31, M '45), vice-president in charge of engineering, Toledo (Ohio) Scale Company, has joined the American Safety Razor Corporation, Brooklyn, N. Y., as director of engineering. Prior to his years with Toledo Scale Company, Mr. Mallory was a group leader in the Radiation Laboratory, Massachusetts Institute of Technology, Cambridge; professor of mechanical engineering, University of Wyoming, Laramie; and head of the Department of Engineering, Valparaiso (Ind.) University. A mechanical engineering graduate of Valparaiso University, Mr. Mallory received his masters degree in electrical engineering at the University of Michigan. He is a member of Tau Beta Pi, the National Society of Professional Engineers, and the American Society for Engineering Education.

H. A. Winne (AM '16, F '45), vice-president of engineering, General Electric Company, Schenectady, N. Y., has been named to a post performing special assignments for the president of General Electric. In his new position, Mr. Winne will serve in a consulting capacity in engineering and also will spend several weeks abroad conducting an investigation on engineering progress in the electrical industry of European countries. He has served on the following AIEE committees: Application to Iron and Steel Production (1930–38); Electric Welding (1934–40); and Edison Medal (1947–52).

V. L. Crabb (M '48), Ohio Brass Company, Mansfield, has been named district manager in the Cincinnati area. Mr Crabb has been a member of the Ohio Brass organization since 1941 when he joined the Mansfield engineering staff. He was later placed in charge of the high-voltage electrical laboratory in Barberton, Ohio, and, since 1950, has been in Mansfield handling engineering duties in the power utilities sales department.

J. V. McGuire (AM '47), manager, substation section, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been appointed sales manager of the Switchgear Department. Mr. McGuire joined Allis-Chalmers in 1940 after receiving his electrical engineering degree from Lehigh University. He is a member of the AIEE Committee on Industrial Power Systems (1952–53) and the Committee on Substations (1952–53). **G. W. O'Keefe** (M '46), sales engineer in charge, circuit breaker sales, Allis-Chalmers Boston Works, Hyde Park, Mass., and **C. F. Kucera** (M '46), engineer in charge, switchgear sales, Allis-Chalmers West Allis Works, Milwaukee, Wis., have been named assistant sales managers of the Switchgear Department. Mr. O'Keefe joined the company in 1919, following his graduation from Tufts College. Mr. Kucera became associated with Allis-Chalmers in 1946. Both Mr. O'Keefe and Mr. Kucera will continue in their present positions and locations.

F. W. Maxstadt (AM '19, M '26), associate professor of electrical engineering, California Institute of Technology, Pasadena, has been appointed registrar of the school. Professor Maxstadt has been a member of the staff since 1919. He graduated from Cornell University in 1916, and later received the master of science and doctor of philosophy degrees from California Institute of Technology. Dr. Maxstadt is a member of Sigma Xi and has served on the AIEE Committee on Electric Welding (1938–44, 1951–53).

F. N. Floyd (AM '16, M '22), engineering manager, United Engineers and Constructors, Inc., Philadelphia, Pa., has been elected a vice-president and director of the company. Mr. Floyd has been with United Engineers since 1928.

K. M. Bausch (M '51), chief electrical engineer, Refinery Division, Bechtel Corporation, San Francisco, Calif., has been appointed chief electrical engineer, Power Division. Mr. Bausch has been associated with Bechtel since 1937.

A. E. Bush (AM '32), statistician, Detroit (Mich.) Edison Company, has been named assistant controller of the company. Mr. Bush was born in Guelph, Ontario, Canada, in 1904 and earned an engineering degree from the University of Detroit in 1930. He has been with Detroit Edison 26 years. He is a member of the Engineering Society of Detroit, the American Marketing Association, and the American Statistical Association.

J. A. Kennedy (AM '50), technical sales engineer, Metropolitan-Vickers Electric Company, Ltd., Manchester, England, has been appointed area sales engineer in charge of the new technical sales office, Brentford Transformers, Ltd., Manchester.

H. S. Hubbard (AM '23, F '48), manager of power transformer engineering, Transformer and Allied Products Division, General Electric Company, Pittsfield, Mass., has been appointed manager of the Transformer Laboratories Department. Mr. Hubbard joined General Electric in 1920, being assigned to the Development Section of the Power Transformer Engineering Division. Later assignments in the division included section head in 1943, assistant engineer in 1944, designing engineer in 1945, division engineer in 1947. He was appointed manager of power transformer engineering in 1952. Mr. Hubbard has twice received the Coffin Award.

B. H. Caldwell (AM '37, F '49), manager, motor engineering, General Electric Company, Lynn, Mass., has been named manager of engineering in the Synchronous and Specialty Motor and Generator Department. Mr. Caldwell joined General Electric in 1935 after serving on the faculty of the University of Texas, Austin, where he received his masters degree in electrical engineering. In 1946 he was named section engineer of d-c motors and generators and in 1950 became assistant manager of engineering. He is a member of the AIEE Committee on Rotating Machinery (1949–53).

A. A. MacDonald (AM '52), section manager, Westinghouse Electric Corporation, Baltimore, Md., has been appointed assistant chief engineer, Communications and Electronics Division, Motorola, Inc., Chicago, Ill. Mr. MacDonald graduated from Yale University in 1940 with a degree in electrical engineering. He is a member of the Institute of Radio Engineers and Tau Beta Pi. He is a member of the AIEE Committees on Radio Communications Systems (1952–53) and Special Communications Applications (1952–53).

R. A. Black (AM '33, M '39), general factory manager, Ohio Brass Company, Mansfield, has been elected vice-president and general factory manager. Mr. Black has been associated with Ohio Brass since 1930. He first spent time in both the Barberton and Mansfield, Ohio, factories, and then came into the sales department and was sent to the New York office in 1931. He returned to Mansfield as a member of the Foreign Trade Department, becoming manager of that department in August 1932. In August 1949, Mr. Black was appointed general factory manager.

G. F. Maedel (M '45), vice-president and general superintendent, RCA Institutes, Inc., New York, N. Y., has been elected president of the technical school. Mr. Maedel joined RCA Institutes in 1933 as the first instructor of the Mathematics Department. He was transferred to the Radio Frequency Department in 1936 and 4 years later was appointed chief instructor. In 1944 Mr. Maedel became assistant superintendent and in 1947 was appointed superintendent. During the following year, he was elected vice-president and general superintendent.

C. H. Haynes (AM '45), Nelson Stud Welding Division, Gregory Industries, Inc., Lorain, Ohio, has been appointed manager of the Patent Department. Mr. Haynes joined the company 2 years ago after 4 years with the patent law firm of Woodling and Krost, Cleveland, Ohio. He is a graduate of Fenn College and Western Reserve Law School. Mr. Haynes is a member of the National and Ohio Society of Professional Engineers.

C. F. Kettering (AM '04, F '14, Member for Life), vice-president in charge of research, General Motors Corporation, Dayton, Ohio, has received the National Society of Professional Engineers Award on the basis of meritorious service to the engineering profession. This is only the third time in the history of the society that the honor has been bestowed.

W. H. Erickson (AM '39, M '46), associate professor of electrical engineering, Cornell University, Ithaca, N. Y., has been advanced to professor; and **N. H. Bryant** (AM '47), instructor in electrical engineering, and **Simpson Linke** (AM '42, M '51), assistant professor of electrical engineering, have been advanced to associate professor. Mr. Erickson has served on the AIEE Committee on Student Branches (1951–52).

A. S. Tusin (AM '43, M '50), resident engineer responsible for statistical quality control development and performance, Reliance Electric and Engineering Company, Ashtabula, Ohio, has been promoted to superintendent. Mr. Tusin joined Reliance in 1942 and has served as resident engineer at Ashtabula since 1947. He is an electrical engineering graduate of Case Institute of Technology and a registered professional engineer in Ohio. He is a member of the American Society for Quality Control.

E. A. Edwards (AM '39, M '49), design engineer, Eastman Kodak Company, Rochester, N. Y., has been appointed assistant director of plant area 7. Mr. Edwards attended Case School of Applied Science (now Case Institute of Technology) and is an electrical engineering graduate of Massachusetts Institute of Technology. He joined the plant's engineering division in 1948.

OBITUARY....

William Allen Dudley (M '27), equipment research engineer, Western Union Telegraph Company, New York, N. Y., died August 7, 1953. Mr. Dudley was born in Colebrook, N. H., November 28, 1895, and received his electrical engineering degree from the University of New Hampshire in 1917. He worked as an equipment man with Western Union in 1917. During World War I he was a flying cadet and later a second lieutenant in the United States Air Service. Mr. Dudley returned to Western Union in 1919 and joined the engineering department in 1920. He served as engineer of automatics and became automatic research engineer of Western Union's development and research department in 1943. He was named equipment research engineer in 1949. During World War II Mr. Dudley developed the overseas radio multiplex for the United States Navy. He took a leading part in developing multiplex and varioplex telegraph systems and was an authority on printing and automatic telegraphs. He held many patents on multiplex systems, selective signaling devices, and methods of synchronizing telegraph transmission. Mr. Dudley was a director of the New York Electrical Society.

William Fargo Sims (AM '20, M '26, F '33, Member for Life), retired, Commonwealth Edison Company, Chicago, Ill., died recently. Mr. Sims retired as chief electrical engineer in 1943 after serving the utility 32 years. Mr. Sims was born in Green Bay, Wis., September 14, 1875, and received his bachelor of science degree in electrical engineering from Armour Institute of Technology in 1897 and the electrical engineering degree in 1903. Mr. Sims was a member of the Western Society of Engineers. He had served on the following AIEE committees: Power Generation (1927–37); Electrical Machinery (1934–35); and Education (1942–43).

Kazumi Oura (AM '47), chief test engineer, Kyle Products Plant, Line Material Company, South Milwaukee, Wis., died August 10, 1953. Mr. Oura was born November 3, 1919, in Los Angeles, Calif., and received his bachelor of science degree from the University of Wisconsin in 1943. Since then he had been employed at the Kyle Products Plant (formerly Kyle Corporation). Mr. Oura was a member of the Milwaukee Engineers' Society, a past president of the Japanese-American Citizens League, and a registered professional engineer in Wisconsin.

MEMBERSHIP ...

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before October 25, 1953, or December 25, 1953, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Collins, J. L., Consulting Engineer, Boston, Mass.
Corrigan, H. G., Douglas Aircraft Co., Inc., Santa Monica, Calif.
Davidson, R. W. (re-election), Ebasco International Corp., New York, N. Y.
Gibson, F. H., Ministry of Supply, London, England
Harle, J. A., University of Alberta, Edmonton, Alberta, Canada
Lambert, D. E., A. Reyrolle & Co., Ltd., Hebburn, Durham, England

6 to grade of Member

Flash Picture of Jet Plane Take-off Taken at Night From Blimp Above Carrier

The accompanying illustration is a monochromatic reproduction of the first color photograph ever taken of a jet plane being catapulted from an aircraft carrier at night. The U.S.S. *Antietam* was chosen because it is one of the largest carriers and the most modern carrier in the fleet. It is the only United States carrier with a canted deck permitting simultaneous launching and landing operations.

In co-operation with the Navy, a Sylvania Electric Products photolamp and electronics engineering team designed the required electronics equipment and supervised its installation as well as the wiring of seven 100-flashbulb circuits, each flashlamp having an approximate peak output of 3,000,000 lumens. Each of the seven circuits was wired in series and each circuit was checked with a resistance checker every few minutes from the time wiring was completed in midafternoon until the photograph was taken at 9:21 p.m. The circuits were connected to an especially designed thyratron control circuit.

The picture was taken from a Navy *L*-type blimp (shown on the cover above the *Antietam*) and a radio pulse was used to fire the flashlamps on the carrier and to trip the shutters of the cameras on the blimp. The triggering was done with a push button from a position in a forward gun turret where a photographer could watch the jet as it was catapulted from the carrier. The radio link was established with a Navy transmitter operating on 4 megacycles, modulated at 800 cycles, with a special receiver in the blimp. Special delay circuits were employed and a very-high-frequency voice radio circuit was established between the blimp and the carrier. Those cut in on the circuit were photographers in the blimp, blimp pilot, blimp navigator, the bridge of the *Antietam*, primary flight control, the photographer triggering the shot from the bow, the pilot of the *F9F-6* jet, and the flight-deck control room where the electronics equipment was installed.

Special long focal-length cameras were supplied, along with technical assistance, by Fairchild Camera and Instrument Corporation. The "big shot" was taken with two Fairchild *K-37* aerial cameras mounted in tandem. Two Speed Graphics also were hooked in to the triggering circuit and synchronized as insurance cameras. The photograph being used was taken with one of the Fairchild *K-37s* at *f*/8 lens opening and 1/100 shutter speed. Ektachrome Type *B* film was used and the emulsion was tested thoroughly to determine the exact film speed.

Forty-five poles each 25 feet high were anchored in the deck along the portside. Three reflectors mounted near the top of each pole threw light all the way across the deck while a smaller reflector located about half way up each pole provided "fill-in" lighting near the base of the poles. A 60-foot beam on which six large reflectors were mounted was extended from the bow of the ship to light the plane after it had left the deck of the ship. Additional lights were used along the bulkheads, pointed down at the wake, and strategically placed throughout the superstructure and under parked planes for highlighting. A complete lighting plan was drawn up beforehand based on experimentation with carrier models and then modified to meet actual working conditions by Sylvania engineers.

Courtesy Sylvania Electric Products, Inc.

United States Navy jet plane is photographed as it is catapulted at night from the aircraft carrier Antietam. The picture was taken from a Navy blimp, which is shown on the cover above the carrier, and radio pulses were used to fire the flashlamps on the deck of the ship and to trip the shutters of the cameras on the blimp

Radar System Gives Location of Aircraft Flying Within 30 to 60 Miles of Airport

A new and improved surveillance radar system in operation at Norfolk (Va.) Municipal Airport, gives the control tower the location and flight path of all aircraft flying within a 30- to 60-mile radius of the airport. It assists Civil Aeronautics Administration (CAA) controller in directing each plane via radio through a safe and efficient traffic pattern.

Developed and built by General Electric engineers for the CAA, the new system also has been installed and awaits commissioning by the CAA at 16 other major airports. Systems for seven additional airports are in various stages of installation.

During periods of poor visibility, the new radar can be operated with an airport's precision approach control aids. Because landings under poor visibility require more time than those during normal visibility, the new radar helps the control tower to space and control the arrival of inbound planes so they can be "fed" into the precision approach control system at the safest, most efficient rate.

Only moving aircraft show on the screen of the new radar. This feature, called moving target indication, prevents images of stationary objects such as tall buildings and mountains from appearing on the viewing screen. These images can make it difficult to observe the small pips which indicate an aircraft.

Map overlays are provided for the radar screen. These show the controllers the exact locations of all high obstructions dangerous to approaching aircraft. During periods of poor visibility, planes can be directed safely past these obstructions via radio.

The radar has been designed to insure continuous operation at all times. Each installation will include duplicate stand-by equipment, which can take over instantly in case of electrical or mechanical failure in the operating equipment.

The two equipments operate on different channels, but use the same antenna. The dual-channel system also allows preventive maintenance to be performed on either equipment, while the other is in operation.

The radar set and antenna can be located up to 2 miles from the airport control tower, either for safety or to insure maximum range and performance of the system. Picture information is passed from the remote radar set to the viewing screen in the control tower by means of coaxial cable.

Radar signals from this antenna show flight paths of aircraft on a radar screen in the control tower

The new radar systems have been installed at 16 airports and accepted by the CAA. Four others are being installed at present, and four more have been delivered and await installation crews.

Operational tests and training of operators by regional personnel of the CAA follow acceptance of each radar system, before the system can be commissioned. Commissioning a system includes notification to pilots that the system is operating full time, and is available for use. The system at Norfolk, Va. already has been commissioned.

The new radar systems which have been accepted will serve the cities of Newark, N. J.; Philadelphia, Pa.; Detroit, Mich.; Norfolk, Va.; Houston, Tex.; Jacksonville, Fla.; Indianapolis, Ind.; San Francisco, Calif.; Birmingham, Ala.; New Orleans, La.; Pittsburgh, Pa.; Oakland, Calif.; Memphis, Tenn.; Portland, Oreg.; Kansas City, Kans.; and Dallas, Tex. The radar currently is being installed at Columbus, Ohio; Cincinnati, Ohio; and Seattle, Wash. Airports to which the radar has been delivered, and is awaiting installation crews, are at Minneapolis, Minn.; Salt Lake City, Utah; St. Louis, Mo.; and Milwaukee, Wis.

Screen of surveillance radar system shows traffic controller location and flight path of every aircraft within 30 to 60 miles of the airport and assists him in directing each plane through a safe traffic pattern

Program Announced for Joint ASEE-ECPD Conference

The program has been announced for the joint meeting of the American Society for Engineering Education (ASEE) and the Engineers' Council for Professional Development (ECPD) to be held October 14–17, 1953, at the Hotel Statler, New York, N. Y. The theme of the meeting is "Civilization Is Dependent Upon the Growth of the Engineering Profession."

Members of professional engineering societies are urged to take this opportunity to become acquainted with the progressive program for engineering education being promoted through the co-operative efforts of ASEE and ECPD. The sessions will afford participants a special opportunity to meet and discuss with the leaders in engineering education the latest advancements in curriculum and practice.

A special panel on "Engineering Manpower Utilization" sponsored by the Engineering Manpower Commission (EMC) will present case histories of better utilization methods. It is the belief of EMC that this meeting will be the first of its kind to be devoted entirely to the working details aimed at improving the utilization of scarce engineering talent.

The Engineering College Research Council (ECRC) and the Engineering College Administrative Council (ECAC) also will hold meetings during this time.

The program of the conference is as follows.

Wednesday, October 14

8:00 a.m. **ASEE Executive Board Meeting**

Breakfast

10:30 a.m. **Meeting of ASEE Executive Board with Chairmen of ASEE Divisions**

12:00 noon. ECRC Executive Committee Meeting

Luncheon. Eric A. Walker, presiding

2:00 p.m. ASEE General Council Meeting

Council members only. L. E. Grinter, presiding

6:30 p.m. ASEE General Council Dinner

Council members only

7:30 p.m. ASEE General Council Meeting

Council members only. L. E. Grinter, presiding

Thursday, October 15

The following meetings and luncheon sponsored by the ECRC and the ECAC are open to all ASEE and ECPD members and representatives

9:30 a.m. Conference theme: Creativeness in the Arts

Eric A. Walker, vice-president, ASEE, presiding

The morning program will present speakers of national reputation for creative achievement in art, poetry, and music

12:30 p.m. Luncheon, Georgian Room, Hotel Statler

L. E. Grinter, president, ASEE, presiding

Address: "A Psychologist Looks at Creativeness, Its Environment and Its Measurement." Morris I. Stein, University of Chicago

2:00 p.m. Conference theme: Creativeness in Engineering

W. L. Everitt, vice-president, ASEE, presiding

The Engineering Point of View. *Maurice Nelles*, Borg-Warner Laboratory

The Industrialist's Point of View. *Fred Olson*, Olin Industries

6:30 p.m. ECAC Executive Committee Meeting

Dinner. W. L. Everitt, presiding

6:00 p.m. Informal Dinner for ECPD Members

7:00 p.m. Closed Session—ECPD

8:30 p.m. ECPD Open Session

Committee reports, reports of society participation in ECPD, adoption of budget, election of officers for 1953–54

Friday, October 16

9:30 a.m. Engineering Accrediting

Thorndike Saville, chairman; N. S. Hibschman, vice-chairman

The National Commission on Accrediting, the Middle States Association and the Relations of Their Programs with that of the ECPD Program of Engineering Accrediting. *Ewald B. Nyquist*, Middle States Association

Our Neglected Future Engineers. *Gregory Dexter*, Consulting Engineer, Scarsdale, N. Y.

Findings of the ASEE Educational Evaluation Study as They Relate to Accrediting. *L. E. Grinter*, University of Florida

Discussion on the foregoing presentations

Summary of Discussion. *S. C. Hollister*, Cornell University

12:30 p.m. Luncheon

Colonel L. F. Grant, chairman, ECPD, presiding

Address: "Water Problems on the Canadian–U. S. Boundary." General A. G. L. McNaughton, chairman, Canadian Section, International Joint Commission

2:30 p.m. Session

T. H. Chilton, chairman, EMC, presiding

Post College Training

Plans and Results of ECPD Experimental Training Program at Cincinnati. *Cornelius Wandmacher*, chairman, ECPD Training Committee

Engineering Manpower Utilization Panel

Case histories of better utilization methods presented by H. N. Muller, Jr., Westinghouse Electric Corporation; Leslie H. Middleton, The Electric Autolite Company; Chester Brisley, Calumet and Hecla, Inc.

7:00 p.m. Annual Engineers Dinner

All members of ECPD participating societies are cordially welcome

Henry T. Heald, vice-chairman, ECPD, presiding

ECPD Annual Report. Colonel L. F. Grant, chairman, ECPD

Address: "Industry and Engineering Education." Horace P. Liversidge, Philadelphia Electric Company

Saturday, October 17

Open for committee meetings as needed

Future Meetings of Other Societies

American Society of Civil Engineers. Annual Meeting. October 19–23, 1953, Hotel Statler, New York, N. Y.

American Society for Quality Control. 8th Mid-West Conference. October 8–9, 1953, Masonic Temple, Davenport, Iowa

American Standards Association. 35th Annual Meeting. October 19–21, 1953, Waldorf-Astoria Hotel, New York, N. Y.

Association of Iron and Steel Engineers. Annual Convention. September 28–October 1, 1953, Hotel William Penn, Pittsburgh, Pa.

Bureau of Aeronautics and United States Naval Air Development Center. Symposium III on Simulation and Computing Techniques. October 12–14, 1953, University of Pennsylvania, Philadelphia, Pa., and Naval Air Development Center, Johnsville, Pa.

Conference on Industrial Hydraulics. 9th National Conference. October 8–9, 1953, Hotel Sheraton, Chicago, Ill.

Eastern Electrical Wholesalers Association. 2d National Electrical Industries Show. September 29–October 1, 1953, 69th Regiment Armory, New York, N. Y.

Electric League of Western Pennsylvania. 4th Industrial Electric Exposition. October 6–8, 1953, William Penn Hotel, Pittsburgh, Pa.

Engineers' Council for Professional Development. Annual Meeting. October 15–17, 1953, Hotel Statler, New York, N. Y.

National Association of Corrosion Engineers. South Central Region Meeting. October 7–9, 1953, Mayo Hotel, Tulsa, Okla.

National Conference on Tube Techniques. October 13–15, 1953, Auditorium of the Western Union Telegraph Company, New York, N. Y.

National Noise Abatement Symposium. 4th National Symposium. October 23–24, 1953, Armour Research Foundation, Chicago, Ill.

National Safety Council. 41st National Safety Congress and Exposition. October 19–23, 1953, Chicago, Ill.

New York Audio Fair. 1953 Audiorama. October 14–17, 1953, Hotel New Yorker, New York, N. Y.

Radio Technical Commission for Aeronautics. Fall Assembly. October 22–23, 1953, Sheraton Park Hotel, Washington, D. C.

Society of Automotive Engineers. International Production Meeting. October 29–30, 1953, Royal York Hotel, Toronto, Ontario, Canada

Society of Automotive Engineers. National Aeronautic Meeting, Aircraft Engineering Display, and Aircraft Production Forum. September 29–October 3, 1953, Hotel Statler, Los Angeles, Calif.

The American Society of Mechanical Engineers. Fall Meeting. October 5–7, 1953, Sheraton Hotel, Rochester, N. Y.

High-Speed Electronic Memory Device Seen as Aid in Solving Complex Problems

Successful experimental operation of a very-high-speed electronic memory device that promises to help solve scientific and economic problems too vast and too complex for the present capabilities of electronic computers was revealed recently by Dr. Jan A. Rajchman, a physicist of the Radio Corporation of America (RCA) Laboratories Division.

The new memory device, which combines the feature of high speed with a potentially huge information storage capacity, was described by Dr. Rajchman at a symposium on digital computers sponsored by the Argonne National Laboratory. Designed at the David Sarnoff Research Center of RCA, Princeton, N. J., the device consists basically of 10,000 tiny ring-shaped magnets woven on thin wires.

The memory section often is considered the weakest link in present-day computers, Dr. Rajchman said. Various memory systems now in use are either fast in receiving and giving out information or they can store vast quantities of information, but none has been able to do both. Besides, he said, many systems are not completely reliable, that is, they tend to forget or scramble some of the information they have stored before it is wanted by the parts of the computer that do the actual computing.

Dr. Rajchman said the new device appeared to offer these significant advantages for computers of the future.

1. It can memorize or recall a bit of information in a few millionths of a second.
2. It can store 10,000 bits at any one instant. With 100 such devices connected together, which is theoretically possible, a million bits could be stored. A million bits is more than would be needed to translate five solid pages of a newspaper into the memory's language.
3. It potentially has a very high degree of reliability, since its tiny magnetic cores never wear out no matter how much information is fed in or out. Besides, a core could hold the same bit of information for years, if this were desired.
4. It promises to be relatively inexpensive, as memories for computers go.

The heart of the present 10,000-core memory, Dr. Rajchman explained, is a grid—or matrix—of 100 closely spaced wires at right angles to which run 100 more wires.

At each intersection of the wires is a magnetic core. Through the center of each core runs one vertical wire and one horizontal wire.

The cores, which are about the size and shape of the typewritten letter "o" and 1/15 inch thick, are made of a special ferromagnetic spinel, a ceramic-like material. This special magnetic material, which is easily molded on automatic machines, was developed by RCA Laboratories Division along with equipment for rapidly stamping and testing the individual cores.

The magnetic material of the cores is such that when there is an electric current of a certain intensity flowing through the two intersecting wires, a core will switch its magnetic polarity from positive to negative, or negative to positive, depending upon the direction of the current.

Current of the same intensity in one wire alone is not enough to trip the polarity. Thus only when currents are flowing in both wires, will the core at their intersection flip into opposite polarity (if it is not in that state already) causing the core to "memorize" one bit of information.

Thus by applying a current to a particular horizontal wire and a particular vertical wire only the core at their intersection may be tripped.

Recalling, or reading out, information from the memory also is accomplished by operating on one core at a time. The operation is so fast that 100,000 bits can be withdrawn in a second.

The core to be interrogated is subjected to pulses along its two intersecting wires. If the core is tripped into opposite polarity, its reversal of polarity creates an electric signal in a wire that runs through the center of all 10,000 cores. If it is not tripped, no signal appears in the common wire. In either case, the nature of the bit of information it contains is determined. If the core is tripped in reading out, it is automatically returned to its original state by associated circuits, thus no permanent erasure of information need take place.

The basic principles behind the new device, which is formally called the "Myriabit Magnetic Core Matrix Memory," were incorporated in an earlier experimental memory completed by Dr. Rajchman last year which had 16 horizontal and vertical wires, thus a storage capacity of 256 bits. In summarizing the progress his research group has made since, he said:

"Ferrospinel magnetic materials with rectangular hysteresis loops were developed in the middle of last year. By the use of automatic molding and testing machines it became practical to envisage memories with capacities in tens of thousands of bits. The basic problems in the realization of such memories are the switching and readout methods by which fast random access can be obtained efficiently. Successful solutions to these problems are demonstrated in the experimental 10,000 bit memory.

"Last year, on the basis of a memory with 256 bits, we predicted that in the near future storage capacities of thousands or tens of thousands would be achieved and capacities of millions in a more distant future. As the first part of this prediction is now realized we venture to reiterate the second. Of course, this will require great innovations in construction techniques and still further improvements in magnetic switching. But we have no doubt that memories in which random access to millions of information bits in a few microseconds will be available at a relatively low cost.

"This will usher in a new era in information-handling systems which may have profound consequences, not only in scientific computations, but wherever complicated or repetitive computations burden our lives."

Teaching and Research Awards Available Under Fulbright Act

Announcement has been made of Fulbright awards for University Lecturing and Advanced Research for the academic year 1954–55 in Europe and the Near East, Japan, and Pakistan. Countries interested in electrical engineering lecturers are Italy at the Istituto Elettrotecnico Nazionale "Galileo Farraris," Turin, and Pakistan, at the University of Peshawar.

Copies of the announcement, as well as general information about the program, are available upon request to the Conference Board of Associated Research Councils, the Committee on International Exchange of Persons, 2101 Constitution Avenue, N. W., Washington 25, D. C. Application forms are supplied upon the request of individual applicants to the committee and upon completion should be returned to the committee. To be accepted in the current competition, they should be postmarked no later than October 15, 1953.

Oak Ridge Announces Courses in Radioisotope Techniques

The series of basic courses in the techniques of using radioisotopes in research continues to be offered at regular intervals by the Special Training Division of the Oak Ridge Institute of Nuclear Studies. Starting dates of the next three courses are January 4, February 8, and March 15, 1954. Applications and supporting letters must be received 3 months in advance of the starting date.

The courses are offered to enable mature research personnel to obtain in a short time (4 weeks) sufficient facility in the use of radioisotopes to apply them safely and efficiently to their own research problems. Since the demand for this type of training exceeds the facilities for supplying it, the course is designed for university faculty members, group leaders of research teams, and other individuals who will impart the training to additional persons.

No formal course requirements have been established, although experience with past courses has demonstrated that an advanced degree or a bachelors degree supplemented by extensive research experience is necessary for the individual to participate profitably in the course, and participants will be selected accordingly. Participants are selected by a committee representing the institute and the Isotopes Division and Oak Ridge Operations Office of the Atomic Energy Commission.

Applications and additional information may be obtained from the Special Training Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn.

Magnetic Memory System May Aid in Solving Air Traffic Problems

A "magnetic memory system" which may solve many of the problems of air traffic control by electronically storing and comparing flight plans of as many as 2,000 airplanes at once is being developed for the Civil Aeronautics Administration (CAA).

The new electronic system, developed by Remington Rand, Inc., will be ready for demonstration soon. Following installation of the equipment there will be extensive evaluation and testing by the CAA to study application of the system to a variety of problems.

Part of a system which the CAA and the Air Navigation Development Board are developing for future air-traffic control, the new Flight Plan Storage unit includes a drum, on which magnetic marks made on the surface of a revolving cylinder within the drum can be read with lightning speed.

Information on departure times, fuel loads, destinations, routes, payloads, and other data contained in airplane flight plans is transmitted to the system over teletype. The information is then compared with other flight plans already recorded on the magnetic surface, and revised, cancelled, or brought up to date, according to the circumstances.

The results are transmitted back to the sending station, completing an automatic circuit of information in which no human operation is required. The advantage of the magnetic drum system is the great speed and accuracy with which the information is received, compared, corrected, and transmitted back to the sender.

The new system will be used to record hundreds of flight plans, each specifying the places and times of departure and arrival, check points over which the aircraft will pass, and pertinent information as to identification, speed, fuel load, and other data on the aircraft itself.

In the process of filing a flight plan, the magnetic drum searches its records for all other flight plans with similar or identical details, covering the entire 2,000 flight plans in appreciably less than half a second.

The magnetic memory is also adaptable to air-line passenger reservation systems and other filing and checking systems requiring high-speed data handling.

The primary advantage of this new system over human and mechanical operations now used to control air traffic is the speed with which it processes the large volume of information. The magnetic drum processes teletype characters at a rate of 23,000 per second and can retain in its memory up to 312,000 characters, either figures or letters.

The basic operating principle is similar to that of punched-card record keeping. Each hole in a punched card has special significance due to its position on the card. In the magnetic drum system, each magnetic mark has special significance by virtue of its position with respect to the axis and circumference of the drum.

Another aspect of this system, also very similar to punched-card record keeping, is that data sought from its place in the storage drum are identified solely by an inspection of significant items within each data group. Thus the flight plan for a specific aircraft is not identified by its having any specified location on the magnetic drum surface, but

by an inspection of the characters within the flight plan which identify the aircraft. In punched card systems it would be necessary to search through the cards for the one bearing the proper identification characters. In the magnetic drum system an equivalent search is performed, but at a rate of 114,000 characters per second. At this rate, a search through the first 18 characters of all 2,000 flight plans is completed and the desired flight plan is selected for processing in 0.4 second.

Working at this speed, the magnetic-drum memory system is able to supply messages for transmission at a rate which would require 100 teletype lines to handle the peak load.

This system has been designed and built to perform automatically a search of its entire contents once each 10 minutes and select for transmission all messages which contain certain relevant information. Each of these messages is then automatically transmitted over a teletype network to the particular station specified in the stored flight plan.

Supertransistor Types Developed by Sylvania

Two new supertransistors that are expected to outperform current models have been developed by Sylvania Electric Products, Inc.

The new types, known as tetrode and pentode transistors, are expected to provide greater reliability than earlier models and will result in more simplified circuits.

James J. Sutherland, general manager of the electronics division, explained that since tetrode and pentrode transistors have more elements than triode or standard transistors, they can serve as replacements for triodes on a one-for-two or one-for-three basis in some applications and will permit building of even more compact electronic equipment than the triode will permit.

The new transistors will cost between three and four times the current price of triodes and are expected to be available commercially in the fall.

New Camera Photographs Microscopic Particles

A new camera for photographing microscopic particles floating free in the atmosphere has been announced by Stanford Research Institute.

The current issue of the institute's news bulletin, *Research for Industry*, describes the experimental camera as being able to photograph aerosols (air-borne solid or liquid particles) as small as one two-thousandth of an inch.

Institute scientists currently are putting their aerosol camera through exhaustive tests. The pilot model will undergo continuous modification based upon operating experience.

Paul L. Magill, technical director of the air research laboratories, says, "The aerosol camera will give air researchers an opportunity to study aerosols in their natural state. Previous microscopic techniques have required collection of the particles on slides."

When fully perfected, the 500-pound camera should indicate whether or not the process of settling or precipitating particles upon a slide alters or destroys some of them, according to Mr. Magill.

The camera's depth of field is 200 microns.

Instead of a mechanical shutter, pulsed flashes of a narrow-beam light provide the film exposure. The flashes—of 2,000,000 candlepower intensity—may be 1, 4, or 10 microseconds duration, or from one millionth to ten millionths of a second.

The number of flashes may be regulated at any number up to 100 exposures per second. Approximately 15,000 volts are delivered to an air-cooled flash tube for the illumination.

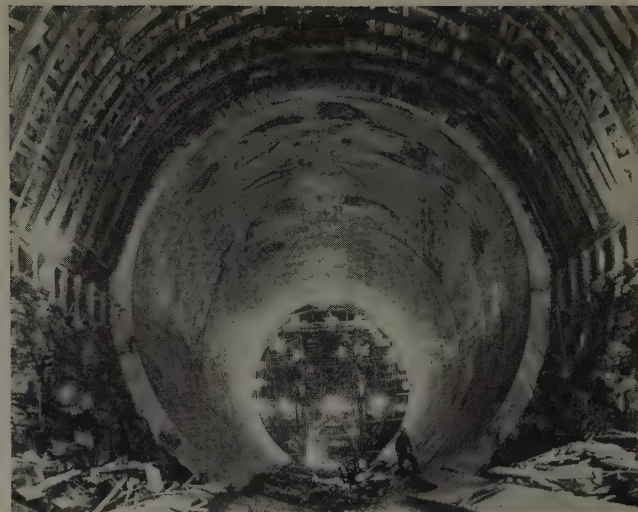
In a "pea-soup" fog, scientists have counted up to 2,000 aerosol particles per cubic inch. Since aerosols are constantly circulating, it is calculated that 12 exposures would be required to catch at least one particle.

A moderate fog would require 10 to 20 times as many exposures to be sure of finding an aerosol particle. The camera's design allows its operator to expose each 5- by 7-inch film as many times as desired.

Stanford scientists have made as many as 6,000 exposures on a single film without clouding or obscuring any image. Aerosols in the field of focus show up black.

The apparatus is portable and therefore adapted to field work wherever the air is to be studied.

Mr. Magill says the camera may enable scientists for the first time to follow and record the history of an unstable aerosol particle over a short period.



One of the twin tunnels partly lined with 3-foot lining of concrete. Visible in the background are the Blaw-Knox steel forms

Steel Forms Used to Build Tunnels for Power Project

Steel forms made by Blaw-Knox Company and used for concrete setting are aiding in the construction of a pair of gigantic tunnels that will divert water from Niagara Falls to the new $300 million electric power station being erected in Canada.

The water will be taken from the Upper Niagara River, near Chippawa, 2 miles above the Falls. The twin tunnels will transport it under the city of Niagara Falls, Ontario, and take it below the Falls for a total journey of $5^1/_2$ miles. There the tunnels will link up with a $2^1/_4$-mile surface canal that then will deliver the water to the Sir Adam Beck Generating Station.

Actual site of the power plant is 6 miles below the Falls, on the side of a 300-foot cliff of the Lower Niagara River Gorge. The plant will have a generating capacity of 1,200,000 kw. Four of its 12 generating units are expected to be running next year, while the remainder will reach full operation by 1957.

Among the largest in the world, the tunnels will have a rough diameter of 51 feet. Circular concrete linings, 3 feet thick, will reduce the final diameter to 45 feet. The lining will require nearly 1,000,000 cubic yards of concrete.

On the average, one-fifth of the total flow of Niagara, amounting to 26 billion gallons of water per day, will pass through the tunnels.

High-Altitude Inverters Granted Engineering Approval

Jack and Heintz, Inc., has announced that its new *F137* inverter (motor-generator) has completed Air Force altitude cycling tests for 50,000-foot operation (full qualification dependent on flight test results). This unit is the first in its volt-ampere rating reported to have completed altitude testing and given a production release by the military.

Capable of 1,500-volt-ampere output at 50,000 feet and 20 degrees centigrade ambient temperature, the 115-volt 400-cycle single-phase inverter helps free aircraft of such critical high-altitude inverter problems as overheating, insulation breakdown, and excessive brush wear. Function of the inverter is to convert d-c to a-c power for instruments, controls, and other aircraft accessories.

The *F137* inverter is a substantially modified version of the company's standard rotary inverter. The major design modifications for high-altitude operation include: improved electrical insulation; redesigned commutators and brush arrangements; new housing configuration for better air flow; and a new speed and voltage regulator assembly. This new regulator, designated *FRS*, combines into one the functions formerly performed by two separate units the speed governor and voltage regulator.

According to Joseph Mulheim, chief

engineer, this 50,000-foot inverter is the first in a series of significant new developments.

"The *F137*," states Mulheim, "will be followed shortly by production of the *F147*. This inverter, capable of 2,500 volt-amperes at 50,000 feet, has just been granted a production release by the Procurement Division of the Air Materiel Command.

"We are also pioneering the design of an environmental-free 2,500-volt-ampere inverter for much higher altitudes and ambient temperatures in accordance with an Air Force development contract."

Silicone Rubber Compound Made in Ordinary Rubber Molds

Silicone rubber parts now can be produced in molds originally designed for natural and synthetic rubber parts according to the General Electric Company's silicone products department which has developed a low-compression-set rubber with only half the shrinkage after molding of conventional silicone rubber compounds.

Recommended particularly for capacitor bushings and for *O*-rings and packings in engines where gaskets and seals must remain effective under sustained pressure, the new compound has a compression set of only 8 per cent after 22 hours at 300 degrees Fahrenheit as compared with nearly 100 per cent for organic rubber and about 75 per cent for general-purpose silicone rubber. Its water absorption is an unusually low 1 per cent after immersion for 1 week at 70 degrees centigrade.

The new silicone rubber is designated *SE-360* and can be used to produce highly uniform parts from ordinary rubber molds. It has a total linear shrinkage of 3 per cent after oven cure. Similar compounds generally shrink 6 per cent or more. This low shrinkage feature is expected to effect a saving in the amount of compound required. Conventional press cycles of about 15 minutes at 250 degrees Fahrenheit can be used, followed by a 24-hour oven cure at 480 degrees Fahrenheit to obtain the manufacturer's stated physical properties for the new silicone rubber compounds.

SE-360 silicone rubber is currently available as a 60-durometer compound. It can be used as a base stock and modified by rubber fabricators to yield 70- or 80-durometer compounds.

Lifeboat Radio Contains Newest Safety Features

Approval has been granted by the Federal Communications Commission to the Radiomarine Corporation of America on its model *ET-8053*, lifeboat radio set. The new set also complies with the rules and regulations of the International Radio Conference and the Safety of Life at Sea Convention. The newest safety features have been incorporated in the set. The compactness of this complete lifeboat station contributes greatly to its safety. The entire set (metal cabinet, automatic keyer, hand generator for power supply, and all necessary material for an antenna system) weighs less than 60 pounds, and can be carried by one person in an emergency. If the set must be hurled overboard, it is adequately constructed to stand the shock and is buoyant. This was proved when, in recent tests, it was dropped 20 feet into the water and floated without damage.

Possibly the set's strongest feature is the fact that any layman can operate it.

Normally, the set would be operated by two men, one cranking on each side of the set; although it may be operated by one man if necessary. This generates power for operation on either one of two distress frequencies, 500 or 8,364 kc.

Model *ET-8053* may be operated automatically or manually. When it is on "automatic," the cranks generate power for an automatic keying system, driven by a constant-speed motor. This automatically transmits, on 500 kc, the international alarm signal (a series of 12 4-second dashes with 1-second spaces between dashes which requires 1 minute), followed by the international distress signal transmitted three times within the next 15 seconds.

The keying device then switches the circuits automatically to 8,364 kc. Three international distress signals are transmitted on this frequency followed by a long dash lasting 30 seconds. The long dash permits shore-based direction finder stations to take a radio bearing on the signal and "pin-point" the eventual rescue operation. Transmission then reverts to 500 kc and the sequence is repeated.

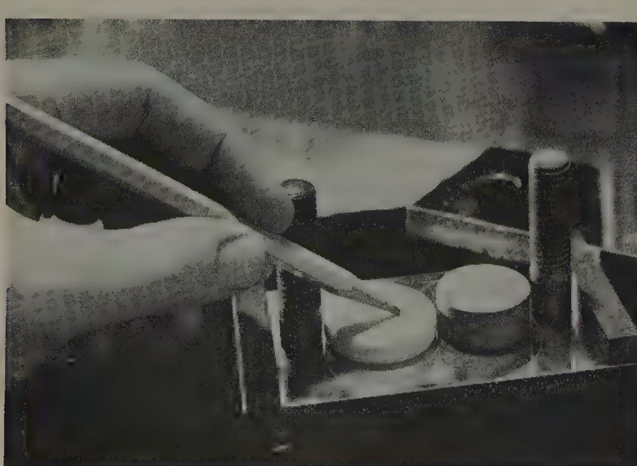
Transmissions also can be made manually on either 500 or 8,364 kc by tapping out the message on a telegraph key directly on the face of the set. Then, by switching the radio receiver into the circuits, 2-way communication is obtained.

All equipment is stowed directly inside the set itself. Even the antenna, which extends to a height of 15 feet when assembled, is housed in the front cover. The antenna is essentially a sectionalized aluminum rod, spring loaded and made up of 11 sections. These are permanently fastened to one another by internal flexible cables. Each section has a built-in socket which fits into its adjoining mate permitting quick assembly with no loss of parts.

In the Radiomarine version of the lifeboat set, the antenna fits directly into a Teflon insulator atop of the set itself. To protect the antenna and prevent it from wind-whipping, it is secured by means of four pieces of flexible wire, each 8 feet long, connected near the top of the rod and then stayed through Teflon insulators. After it is lashed to the sides of the boat, it gives a mast effect. Such an arrangement increases the range of the set as well as braces it. If the rod is lost or damaged, a single-wire antenna can be run from the top of the set to the mast. Extra wire and insulators are stowed in the cover. To aid the operator in making certain power is being sent out through the antenna, there is a separate tuning indicator for each frequency directly on the front panel itself.

The cabinet is reinforced internally to withstand the drop test. The front cover, held in place with spring latches, has a watertight gasket and all front panel devices, since they are exposed to the weather during operation, have rubber seals.

A heavy plastic spiral-bound book that is weather-resistant and contains complete operating instructions, is attached to the front of each set. Crank handles are set high enough for maximum leverage and easiest turning. Sturdy hook clamps permit speedy, effective mounting on lifeboat thwart and attached metal handle atop container permits one or two persons to carry it with ease. The safety rope and web straps for mounting to the thwart are chemically treated to prevent rotting.



The 8-per-cent compression of SE-360 silicone rubber as compared to general-purpose silicone is clearly illustrated. The general-purpose material recovered only 10 per cent of its original height while SE-360 recovered 92 per cent

Robot-Eye Units Monitor Uranium Rolling Process

Radiation detection devices which literally "see the heat" comprise the heart of a newly developed robot system that is 10 times faster and 2 to 5 times more accurate than previous systems in monitoring critical temperatures during uranium rolling operations, it was reported recently by the Minneapolis-Honeywell Regulator Company.

The new system, the first ever designed to supervise automatically this vital phase of production rolling of uranium ingots, has been installed in the recently opened uranium mill built by Birdsboro Steel Foundry and Machine Company, Fernald, Ohio. The Atomic Energy Commission's Ohio production center is now in volume production rolling uranium into ingot bars later used to produce fissionable materials.

W. P. Wills, director of the division's research and development activity, explains that the objective was to improve the accuracy of temperature measurements which are important to uranium and other rolling processes. The radiation devices, called radiamatic pyrometers, function as

"pickup" elements which are comparable to electric eyes. They detect the temperature—or heat—of the uranium ingot and relay the information to a series of electronic recording instruments. This information, which may report temperature conditions at several points in the production line, permits a single operator to make necessary adjustments.

By conventional procedures mill operators determine temperatures by utilizing colored crayon sticks, each with specific melting points. To ascertain ingot temperatures the operator stops the operation and marks the ingot with the crayon stick. If the crayon stick with a melting point of, say, 1,000 degrees Fahrenheit, melts on application, the operator knows the ingot is at least that hot. A crayon stick with the next highest temperature is then applied. If this does not melt, the operator then calculates the ingot temperature lies somewhere in between.

The new system, by permitting measurements while the ingots are being processed, markedly speeds up the production operation. It is estimated that the new electronic system provides a temperature reading, at one or a dozen points, in something like 1 or 2 seconds, or 10 times faster than the crayon method. The accuracy of the temperature reading is improved also, ranging from 2 to 5 times better.

The automatic monitoring is similar to systems developed by the company for use in steel mills to determine temperatures of processed steel.

Silicon Alloy Junction Diode Developed by Bell Laboratories

A new electronic device which may result in revolutionary advances in telephone switching systems and in many kinds of computers has been created by Bell Telephone Laboratories.

Described as a silicon alloy junction diode, it serves as the electronic equivalent of a tiny 1-way switch. Thus it acts as a rectifier. Also, it is capable of operating thousands of times faster than its mechanical counterparts.

The new diode contrasts sharply with a conventional 2-element vacuum tube in that it requires no filament or vacuum. It has an encased element no larger than a match head, and is an accomplishment growing out of transistor research and development.

At Bell Laboratories, where the transistor was invented, silicon crystals were prepared containing controlled traces of an impurity. This reduces the normally high resistance of the mineral and enables rectification.

Under the sponsorship of the Laboratories, the Du Pont Company recently developed a method for the commercial manufacture of high-purity silicon and thus has opened up an unlimited source of the material for electronic usage.

The new diode may be thought of also as the electronic equivalent of a dam between two bodies of water. The water can be made to flow over the dam merely by raising the level of the water on one side. However, lowering the level on this side will not result in the water flowing the other way.

West Engineering Building at the University of Michigan

Preventing an electronic back-flow is never absolutely perfect so the diode is a somewhat leaky sort of dam. In the new silicon diode this back leakage is smaller than in any previous diode, about one ten thousand millionth of an ampere.

Compared with this the leakage currents of vacuum tube diodes may be 1,000 times greater. Another way of describing the device's performance is to say that the ratio of its resistances in the two directions is 100,000,000 to 1.

Like the transistor, it requires no warm-up period; but unlike the present germanium transistor or diode it can operate well under high temperatures. Its lifespan should be almost unlimited.

Present plans call for the use of the new diode in the memory organ of a transistor-operated digital computer. In such a "brain" numbers may be remembered as charges on capacitors. To avoid "amnesia," the charge must be prevented from leaking off.

The silicon diode is ideal for this use.

The charge is admitted through the diode to the capacitor, but the high back resistance prevents it from leaking away. Thus the combination of the diode and capacitor can store a "bit" of information.

Michigan Will Celebrate Engineering Centennial

Emphasis will be on the present and future of engineering as well as the past when the University of Michigan celebrates 100 years of engineering instruction on October 23 and 24, 1953.

The College of Engineering will stage an open house on both days so that the engineering alumni expected back for the centennial can see the work now going on in the engineering buildings.

Registration will get under way late Thursday, October 22, in the Michigan Union and continue through Friday morning. There will be a luncheon in the Union followed by a convocation at 2:30 p.m. presided over by President Harlan Hatcher. Secretary of Defense Charles E. Wilson will be the speaker. His address will be followed by the presentation of honorary degrees and citations.

Robert Moses, New York City's commissioner of parks, will discuss "The Contribution of Modern Engineering to Our Civilization" in Hill Auditorium at 8:30 p.m. Entertainment will be provided by the University's Men's Glee Club.

Saturday morning's convocation in the Rackham Building will stress the past, present, and future of engineering at the university. Harvey M. Merker, of Parke, Davis and Company, will review the century of history and a color film, "The First Hundred," will be shown for the first time.

George Granger Brown, dean of the College of Engineering, will talk about "The College Today and Tomorrow," and James W. Parker, consultant and past president of The Detroit Edison Company, will look ahead with his views on "Engineering the Future."

The campus of the future will be the topic for the concluding convocation Saturday at 1 p.m. The North Campus development will be discussed and a new laboratory to house Engineering Research Institute activities will be dedicated. The laboratory is a memorial to Mortimer E. Cooley, dean from 1904 until 1928, who is credited with molding the college into a world-famed educational unit.

Electronic Flight Duplicators Ordered by Eastern Air Lines

Eastern Air Lines has ordered seven Model *501* Curtiss-Wright Dehmel Electronic Flight Duplicators, it has been announced jointly by the air line and Curtiss-Wright. Delivery of the equipment will be made during the first half of 1954.

Used for advanced pilot instruction, the Duplicators will "fly" like the transports operated by Eastern. Built around a single-seat cockpit equipped with all the basic instruments and controls of an airliner, each Duplicator contains in a single unit six major components embracing flight controls, flight simulating devices, and such radio navigational airs as ILS (instrument landing system); ADF (automatic direction finder); RDF (radio direction finder); VHF (very-high-frequency range); fan marker beacons; and the like.

Capable of simulated cruising at moderate

transport speeds, the Duplicator never moves or leaves the ground. Nevertheless, it gives pilot personnel a realistic sensation of flight through its ability to reproduce accurately both the feel and the sounds of a true aircraft.

Pilots using Duplicators are able to sharpen their techniques for approaches, landings, and for other aspects of flight, including air emergencies that might be encountered aloft.

The instructor, seated just outside the pilot's compartment, has in front of him automatic recording equipment that charts every course movement of the aircraft. At the instructor's disposal, also, is a trouble panel that allows the addition to any training flight of such emergencies as wing and carburetor ice, rough air, and mechanical malfunctions.

Use of this electronic flight equipment will speed the achievement of maximum proficiency by pilots and reduce training expenses because of the extremely low operating costs of Duplicators.

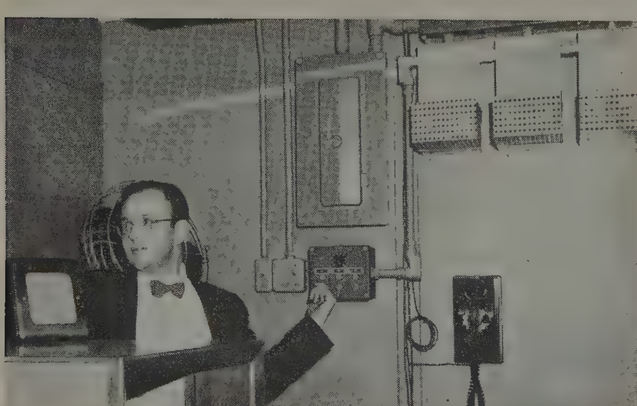
While they are using these units for instrument flying, pilots find four characteristics of Duplicators of unusual importance: 1. radio signals are entirely automatic; 2. the Duplicator reproduces the same inertial effects as a real aircraft; 3. it has an accurate rate of response to control movements; and 4. it achieves rates of closure on a radio beam that are accurate and realistic.

With these requisite characteristics, pilots are able to achieve the fine sense of anticipatory reaction that permits them to guide a plane along radio beams with maximum proficiency.

First Fluorescent Lamp Dimmer Is Installed Commercially

The first commercial installation of a new fluorescent-light dimming system was completed recently in an executive conference room in the general offices of the Ford Division of the Ford Motor Company at Livonia, Mich.

The dimming system, manufactured by the General Electric Company, controls 93 40-watt rapid-start fluorescent lamps in the ultramodern meeting room. The lamps are mounted 34 inches above semitransparent plastic sheets to provide lighting of the luminous-ceiling type. They are divided into three groups which can be controlled individually or collectively by three dimming units.



Three electronic dimming units (upper right) and a brightness selector (lower center) control the first commercial installation of a fluorescent-light dimming system

According to engineers, fluorescent lamps on dimming circuits offer several advantages over filament lamps, such as higher efficiency over the dimming range, lower operating costs, and better color control. While filament lamps become increasingly red as they are dimmed, fluorescent lamps change very little in color over their entire brightness range.

Components of the dimming system, excluding lamps, are a dimming ballast for each operating lamp, a thyratron unit, and an intensity selector. The circuit is designed for 40-watt rapid-start lamps.

The dimming circuit requires a 240-volt supply to the electronic control. Brightness is controlled by a selector consisting of a small potentiometer which can be located either at the electronic unit or any convenient place. Special controls might make use of a selsyn-driven potentiometer to provide automatic control in either direction, or a push-button unit with fixed resistors to provide preselected brightness.

The dimmer does not depend on varying lamp voltage to control light output; it controls the time during which voltage is applied. Changes in light output result from changes in the length of time that current flows through the lamp during each cycle. Sufficient starting voltage is present over the entire dimming range to initiate and maintain the arc. In order to provide proper cathode temperature at low lamp currents, the cathodes are heated continuously.

ISCC Urges Caution in Use of Unscientific Devices

The Inter Society Corrosion Committee (ISCC) has become greatly concerned about the hazards which may result from dependence on certain unproved devices for controlling corrosion and scaling. The committee recommends that caution be exercised in the application of such devices, since any failure to give protection may result in serious damage to expensive equipment where a real problem of corrosion or scaling exists.

The ISCC is made up of about 35 delegates from major technical societies, in the United States and Canada, actively concerned with problems of corrosion control and with the scientific reduction of the economic loss caused by corrosion. By means of this word of caution, and in accordance with its established objectives, the committee seeks to promote the use of the many scientifically sound and effective devices and processes which are presently available and to discourage dependence on unsound and ineffective methods of control.

The committee wishes to draw particular notice to devices which are not based on any understandable scientific principle and which are promoted generally on the basis of testimonials from presumably satisfied customers, unsupported by quantitative data. Special attention is drawn to supposedly scientific explanations which make liberal and incoherent use of such terms as catalysis, magnetism, electronics, radiation, and so on. Such "explanations" do not appear to have any basis in scientific fact.

In some cases recommendations are made by manufacturers that grounding wires of electric circuits, if unfavorably connected to pipes in which the devices are installed, should be rearranged or connected elsewhere. The committee emphasizes that if, because of installation of or after one of these devices has been installed, the electric circuits are not grounded in accordance with the National Electrical Code, serious impairment of the safety of persons and property may result.

Against this background, and in line with its responsibilities, the committee then recommends extreme caution in the application of devices for control of corrosion and scaling that are characterized by supposed operation without any apparent basis of sound scientific principles and for which no adequate engineering performance data are available.

Radar Safety Beacon Recommended for Use in Common System

The development of a Common System Secondary Radar Safety Beacon having characteristics proposed by the Joint Communications-Electronics Committee of the Joint Chiefs of Staff has been recommended by the Radio Technical Commission for Aeronautics (RTCA) as a supplementary aid to primary radar for improving air traffic control and increasing flight safety.

Use of the Radar Safety Beacon offers three principal advantages: 1. Improved reliability of the radar traffic control system; 2. Positive identification of aircraft by use of coded replies; 3. Faster movement of traffic due to closer separation intervals.

It will be particularly effective at distances and under weather conditions which render unsatisfactory the reflected signals of Airport Surveillance Radars (ASR) now in use.

Primary ground radar transmits pulse signals which reflect from aircraft as "echoes." Only a small part of the energy of the original signal is reflected, however, and a very weak signal is returned to the ground. Under adverse conditions, these weak signals can be absorbed in the atmosphere to such a degree that no usable reflection is received.

In the secondary system, the ground signal "triggers" equipment in the aircraft which transmits a reply pulse signal many times stronger than an "echo." In addition, these replies may be coded to provide aircraft identification. This permits closer spacing of aircraft in the traffic pattern by eliminating the need for maneuvers necessary

with primary radar to associate each aircraft with a particular "blip" on the radar scope.

The complexity of air traffic control has increased rapidly and steadily in recent years because of expanding defense needs and increased air traffic at higher altitudes, faster speeds, and over longer distances.

This condition created a need for a more modern system of air traffic control. Primary radar provided much of the necessary improvement, but meteorological disturbances may cause weakening of the reflected signals and a resulting loss of target. Since primary radar does not provide identification of aircraft in a controlled area, time-consuming maneuvers are necessary to establish the association between an aircraft and its "blip."

The secondary radar overcomes such shortcomings inherent in the primary system which make the latter incapable of meeting today's increased requirements under unfavorable conditions.

The amplified signals from the Radar Safety Beacon improve surveillance by providing continuous tracking of all sizes and types of aircraft under all conditions of weather and restriction of visibility. Coded replies by the beacon assure rapid, positive identification of aircraft entering a controlled area or re-identification when continuity of tracking has been lost temporarily by the primary radar. Closer separation intervals of aircraft attain faster movement of traffic, which lessens congestion, and provide more efficient utilization of the airspace and the airport runways.

A report by a Special Committee of RTCA (*SC-64*) specifies among its performance objectives that the secondary radar can operate at ranges up to 200 nautical miles and altitudes of 60,000 feet, with continuous tracking to within 1 mile of the interrogation transmitter. The beacon will be capable of giving ten coded replies in response to interrogation from the ground station and will not interfere with the performance of other radio or radar equipment.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Force on a Conductor in a Slot

To the Editor:

With further reference to the letter to the editor from C. R. Cahn and D. W. Spence (*EE, May '53, pp 474–5*), K. Humburg is the author of an article entitled "Die Entstehung des Drehmomentes in Elektrischen Maschinen," published in *Elektrotechnische Zeitschrift* (Berlin, Germany), volume 71, 1950, page 311, which is on the same subject as the afore-mentioned letter.

K. Humburg gives further references, including one to an article by Professor G. W. O. Howe entitled "Some Magnetic Misconceptions" in the *Electrician* (London, England), volume 115, November 1935, pages 601–02.

Professor Howe also refers to the work of Dr. Searle which was described in the *Electrician*, 1898, page 453.

(The reference on page 475 of the Cahn and Spence letter to the article by L. Fleischmann should be to *Elektrotechnische Zeitschrift*, volume 42, 1921; not volume 32.

H. P. TUCK (M '34)

(Department of Electrical Engineering, The University of Tasmania, Hobart, Australia)

Flowmeter Correction

To the Editor:

An electronic flowmeter was described in the National Bureau of Standards Summary Technical Report *1748*, dated February 1953 (see also the *Technical News Bulletin*, volume 37, number 2). It has been learned since that a flowmeter was described in 1950 which used the same system of switching reversible transducers to obtain a measure of flow: "Ultrasonic Method for Measuring Water Velocity," W. B. Hess, R. C. Swengel, S. K. Waldorf. AIEE miscellaneous paper 50–214 (digest, *EE, Nov '50, p 983*).

Other references which should have been included are the following: (1) "Electromagnetic Flowmeter," A. Kolin, *United States patent 2,149,847*, 1939; (2) "Preliminary Report on Temperature Measurement by Sonic Means," Earl W. Barrett, Verner E. Suomi, *Journal of Meteorology*, August 1949, page 273; (3) Oskar Rutten, *German patent 520,484*, November 1928; (4) J. W. Gray, *United States patent 2,534,712*, December 19, 1950, filed November 30, 1945; and (5) B. O. Stroule, *British patent specification 623,022*, May 11, 1943.

It is regretted that these references were not known at the time the Summary Technical Report was prepared, and that this article gave the erroneous impression that all features of the development were new. The features which appear to be novel are (1) rapid switching, (2) synchronized rectification, and (3) the use of transducers mounted externally.

WILLIAM R. TILLEY

(National Bureau of Standards, United States Department of Commerce, Washington, D. C.)

NEW BOOKS . . . . .

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ELECTRICAL ENGINEERING. By Fred H. Pumphrey. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y., second edition, 1953. 404 pages, 9¼ by 6¼ inches, bound. $8. This text is intended for students specializing in technical fields other than electrical engineering. The first 12 chapters review the basic theory of electric circuits, electromagnetism, electric machinery, and measurements. The last chapters describe typical applications, controls, electrochemical processes, electron tubes, and various specialized applications of importance to civil, mechanical, and electrical engineers.

INDEX. (Massachusetts Institute of Technology, Radiation Laboratory Series, Number 28.) Edited by Keith Henney. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1953. 160 pages, 9¼ by 6¼ inches, bound. $4.50. A complete guide to the 27 monographs of this series, which cover not only the essential features of the work of the Laboratory but also present a full account of the technical developments in the field. The index volume also contains an account of the establishment and organization of the Radiation Laboratory.

THE INDUCTION MOTOR. By Herbert Vickers Sir Isaac Pitman and Sons, Ltd., London, England (distributed in United States by Pitman Publishing Corporation, 2 West 45th Street, New York, N. Y.), second edition, 1953. 531 pages, 9¼ by 6¼ inches, bound. $15. Theory, design, and applications are covered with emphasis on the principles of design. In this edition additional material has been introduced in connection with single-phase machines, selsyns, 3-phase series and shunt commutator motors, and the application of symmetrical components to conditions of unbalance. Fractional-horsepower motors are covered, including typical designs.

INTRODUCTION TO ENGINEERING ECONOMY. By Baldwin M. Woods and E. Paul De Garmo. Macmillan Company, 60 Fifth Avenue, New York 11, N. Y., second edition, 1953. 519 pages, 8½ by 5¾ inches, bound. $6. A textbook for engineering students, in which the relation of such subjects as accounting, valuation, investment theory, statistical methods, and general economics to the management of engineering enterprises is explained. The subject matter remains substantially the same as in the previous edition but the material has been revised to conform with recent developments.

INTRODUCTION TO SOLID STATE PHYSICS. By Charles Kittel. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1953. 396 pages, 9¼ by 6 inches, bound. $7. Solid state physics is a wide field concerned particularly with the special properties exhibited by atoms and molecules because of their association in the solid phase. This introductory text covers crystal structures, thermal and dielectric properties of solids, paramagnetism, ferromagnetism, superconductivity, the free electron and band theories of metals, semiconductors, and imperfections in solids. Theoretical concepts and models of solids are emphasized as being applicable to a wide range of problems.

LOW TEMPERATURE PHYSICS. By Charles F. Squire. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1953. 244 pages, 9¼ by 6¼ inches, bound. $6.50. The properties of matter at low temperature and their adherence to quantum laws are studied. Superfluid helium, superconductivity of metals, the complex magnetic and electric permeability of matter, and the thermal energy in the solid state are extensively discussed, indicating current fields for research. Some experimental methods and apparatus are given.

LUMINESCENCE AND THE SCINTILLATION COUNTER. By S. C. Curran. Academic Press Inc., 125 East 23d Street, New York 10, N. Y., 1953. 219 pages, 8¾ by 5¾ inches, bound. $5.80. A review of current knowledge of the scintillation method of investigating atomic and nuclear radiations, written both for the incidental user of the technique and for those inter-

ested in developing its possibilities. In addition to the main subject, such related topics as secondary emission, photoelectricity, and luminescence are given detailed treatment, and a chapter on applications deals with basic problems such as gamma, neutron, and meson spectroscopy.

PRACTICAL TELEVISION ENGINEERING. By Scott Helt. Rinehart Books, Inc., 232 Madison Avenue, New York 16, N. Y., second edition, 1953. 744 pages, $9^1/_4$ by $6^1/_2$ inches, bound. $7.50. Containing the material which practicing engineers in this field need to solve everyday problems, this book presents a detailed engineering treatment of television transmission and reception. Theoretical and practical aspects of lenses, lighting, cathode-ray tubes, oscillographs, camera tubes, synchronizing generators, video amplifiers, and regulated power supplies are among the topics dealt with.

A MANUAL OF ENGINEERING DRAWING FOR STUDENTS AND DRAFTSMEN. By Thomas E. French and Charles J. Vierck. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., eighth edition, 1953. 715 pages, $9^1/_2$ by $6^1/_2$ inches, bound. $8. This new edition has been rearranged into four basic divisions: fundamentals of shape description, including pictorial sketching, perspective, and intersections; size descriptions, covering dimensioning and the relationship between the drawings and the shop; discussion of basic machine elements; and the section on working drawings, including related specialties—architectural, structural, map, and topographic drawing. The usual information on lettering, the selection and use of instruments, and the making of charts and graphs is included, as are brief glossaries of pertinent terms.

DAS MESSEN HOHER ELEKTRISCHER SPANNUNGEN. By P. Böning. Verlag und Druck G. Breun, Karlsruhe, Germany, 1953. 141 pages, $8^3/_8$ by $6^1/_8$ inches, bound. DM 18.60. Comprehensive description of apparatus and methods used to measure very-high alternating and direct voltages. The book also aims to present sufficient numerical data to allow the independent construction of apparatus. It is intended for engineers engaged in the development and use of industrial high-voltage apparatus and for physicists who use high voltage in research. There is a bibliography.

MODERN RESEARCH TECHNIQUES IN PHYSICAL METALLURGY. American Society for Metals, 7301 Euclid Avenue, Cleveland 3, Ohio, 1953. 335 pages, $9^1/_4$ by $6^1/_4$ inches, bound. $5. Fourteen papers are presented dealing primarily with experimental techniques cutting across the entire field of physical metallurgy. The first three papers fall in the area of optical and electron microscopy. The third paper forms a transition to the next four on diffraction techniques, thus covering electron, X-ray, and neutron diffraction. Then follows a sequence of four papers on single crystal, crystal boundary, and deformation procedures. The final three papers are on ferromagnetic and radioactive methods. In all cases emphasis is placed on the kinds of information that can be obtained.

PHYSICAL SIMILARITY AND DIMENSIONAL ANALYSIS. By W. J. Duncan. Edward Arnold and Company, London, England (distributed in United States by Longmans, Green and Company, Inc., 55 Fifth Avenue, New York 3, N. Y.), 1953. 156 pages, $8^3/_4$ by $5^3/_4$ inches, bound. $5.75. The point of view adopted in this book is that dimensional analysis is a convenient technique for obtaining the quantitative conditions for similarity in behavior of a family of similar physical systems and the consequences of this similarity in behavior. The author first discusses units and measures, geometric and kinematic similarity, and similarity in Newtonian dynamics. Then comes an introduction to dimensional analysis followed by more detailed treatment under the headings of fluid motion, heat, and electromagnetism. There is a special chapter on the use of nondimensional coefficients in engineering design—propellers, pumps, aircraft performance, and so on—and some treatment of special problems such as the deflection of beams.

A POLICY FOR SCIENTIFIC AND PROFESSIONAL MANPOWER. By the Research Staff of the National Research Council. Columbia University Press, 2960 Broadway, New York, N. Y., 1953. 263 pages, $9^1/_4$ by $6^1/_4$ inches, bound. $4.50. This report consists of two parts: a statement of policy for scientific and professional manpower, and a study of the facts upon which the policy recommendations are based. The first part gives the Council's recommendations to government, industry, and educational institutions, designed to provide the nation with adequately trained scientific and professional workers. The second part depicts and analyzes existing shortages, discusses the actual and potential educational attainments of the population, and considers factors impeding the training of capable persons. Separate chapters give detailed appraisals of shortages of engineers, physicists, teachers, and medical personnel. The concluding chapter deals with present public policies and attitudes towards scientists and professional men.

TEXTILE FIBERS, YARNS, AND FABRICS. A Comparative Survey of their Behavior with Special Reference to Wool. By Ernest R. Kaswell. Reinhold Publishing Corporation, 330 West 42d Street, New York 36, N. Y., 1953. 552 pages, $9^1/_4$ by $6^1/_2$ inches, bound. $11. This is an annotated and interpretive bibliography of textile fiber research constituting a survey of over 400 authoritative references. Divided into two sections, Part A discusses such inherent properties of fabrics as density, refractive index, tenacity, rupture elongation, elastic modulus, and resistance to chemicals. Part B discusses form factors such as yarn denier, density, twist, and diameter, also fabric weight, thickness, thread count, and weave. The influence of properties and factors on fabric luster, crease retention, abrasion resistance, and the like is considered, and some conclusions are drawn as to the relative merits of fibers and fabric structures, with special emphasis on the position of wool.

VACUUM-TUBE OSCILLATORS. By William A. Edson. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y., 1953. 476 pages, $9^1/_4$ by 6 inches, bound. $7.50. A systematic and comprehensive treatment of the many factors which affect the behavior of vacuum-tube oscillators. The viewpoint of design is stressed over that of analysis as representing the basic purpose of engineering. The first five chapters present basic characteristics and calculations, subsequent to which the author takes up the several major types, essential aspects of behavior, and various special problems such as tube and thermal noise, automatic frequency control, and so forth. The book is designed to suit the everyday needs of the engineer and is well indexed. There is an extensive bibliography.

WAVE PROPAGATION IN PERIODIC STRUCTURES. By Léon Brillouin. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y., second edition, 1953. 255 pages, 8 by $5^3/_8$ inches, paper. $1.75. Based on lectures given at the University of Wisconsin, this volume includes a variety of problems having a common mathematical background. They extend from electrical engineering to electromagnetism and wave mechanics of the spinning electron. The book includes explanations of electric filters, rest rays, anomalous optical reflections, and selective reflection of X rays or electrons from a crystal, and discussions of 1-, 2-, and 3-dimensional lattices. Some corrections have been made and a brief appendix has been added discussing recent developments and literature.

X-RAY CRYSTALLOGRAPHY. By R. W. James. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., fifth edition, 1953. 101 pages, $6^3/_4$ by $4^1/_4$ inches, bound. $1.75. This small volume is intended as an outline of the main principles underlying the methods of crystal analysis of X rays. No attempt is made to deal with detailed or complicated situations. The successive editions have incorporated new techniques and recent developments.

Library Service

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

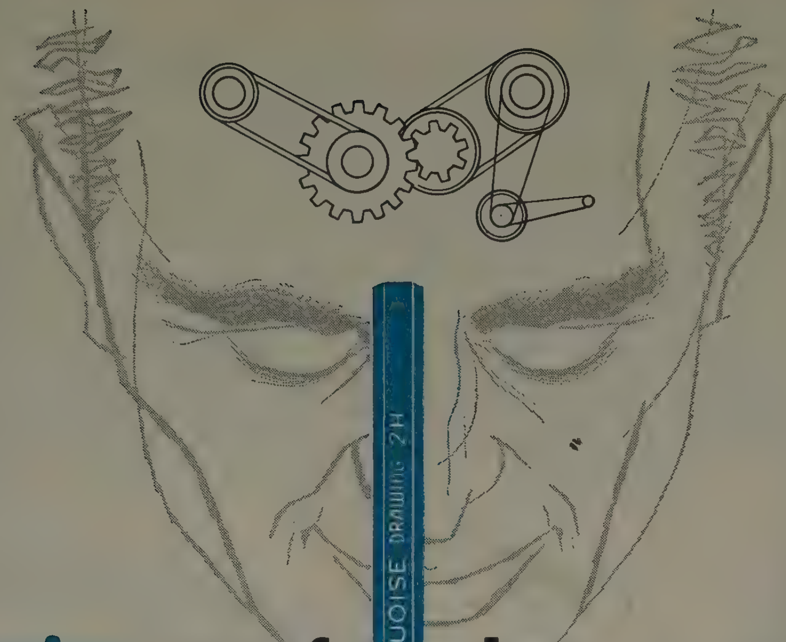
PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

ASTM Specifications for Steel Piping Materials. The December 1952 edition, sponsored by the American Society for Testing Materials (ASTM) Committee *A-1* on Steel, contains the 56 ASTM specifications for carbon-steel and alloy-steel pipe and tubing, including stainless. Materials covered include: pipe used to convey liquids, vapors, and gases at normal and elevated temperatures; boiler, superheater, and miscellaneous tubes; still tubes for refinery service; heat-exchanger and condenser tubes. Specifications for the following materials used in pipe or related installations are also included: castings; forgings and welded fittings; bolts and nuts. The ASTM standard classification of austenite grain size in steel with two sets of charts and the American Standards covering wrought-steel and wrought-iron pipe and stainless-steel pipe are a part of the book. 394 pages. $3.75. Available from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

Code for Protection Against Lightning. In spite of the value of lightning-rod systems for protecting buildings, their use has not proved as effective as possible because of a general lack of information as to the best methods of protection. To enable the public to demand installations designed for adequate protection, the National Bureau of Standards (NBS) has just issued the new edition, Handbook *46*, of "Code for Protection Against Lightning," sponsored jointly by the National Fire Protection Association, AIEE, and NBS. This handbook emphasizes personal precautions and protection of buildings and miscellaneous structures. In addition to including material revised from previous handbooks, the volume contains information on aluminum as a suitable material for lightning protective systems, new rules on grain elevators and on vents and stacks emitting explosive dusts, vapors, or gases, and detailed specifications for lightning rods. 91 pages. 40¢. Order from Government Printing Office, Washington 25, D. C.

Energy in the Overseas Territories. The economic expansion of the overseas territories depends on the possibilities of cheap energy supplies. For the territories of Africa south of the Sahara and Surinam, hydroelectric power is the only local source open to considerable development. This study by the Organization for European Economic Co-operation deals with present power resources in these territories, the foreseeable trend of requirements, and goes on to describe the projects planned, with particular reference to their economic and financial aspects. 48 pages. $1.00. Order from International Documents Service, Columbia University Press, 2960 Broadway, New York 27, N. Y.



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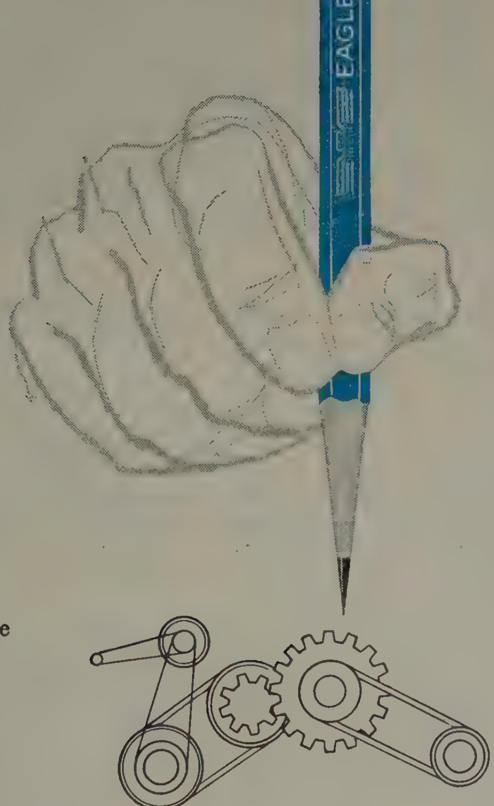

"Electronic" is Eagle's trade name for a blend of crystalline graphites of highest purity, reduced to particles of micronic fineness in our patented Attrition Mill. 100% "Electronic" graphite in every Turquoise lead gives you super-service in four important ways:

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INDUSTRIAL NOTES ....

Westinghouse News. Westinghouse Electric Corporation has purchased the large government-owned plant in Lansdowne, Md., which the company has operated under lease since its construction in 1942. The plant is producing induction-heating equipment, microwave equipment, railroad radios, power-line carrier equipment, radio transmitters, and certain radar components.

The Westinghouse plant at Attica, N. Y., which has been building industrial stokers, will become a branch plant of the Westinghouse Motor and Control Division whose main plant is in Buffalo, N. Y. The Attica plant will produce parts for electric motors and some other products. The present management staff at Attica will remain in charge of operations.

A. M. Cooper has been appointed manager of application engineering of the Gearing Division. He succeeds G. H. McBride, who has been appointed assistant manager of the Switchgear Division.

S & C Promotions. E. J. Sroka has been made director of properties and personnel. A. B. Chilcoat has been named director of purchasing and production. C. C. Martin succeeds Mr. Sroka as manufacturing manager.

Distributor for Multi-Amp. Westinghouse Electric Supply Company, New York, N. Y., has been named distributor for Multi-Amp Corporation, Harrison, N. J., manufacturers of portable high-current test instruments. To assure adequate coverage in the states where Westinghouse Electric Supply does not have sales headquarters, special agreements have been worked out with independent electrical distributors.

Stromberg-Carlson Distributor. Litteral Distributing Company has been appointed distributor of Stromberg-Carlson radio and television products for Indianapolis and the southern two-thirds of Indiana.

Otis Elevator Acquires Company. Otis Elevator Company has announced that it has acquired the Transmitter Equipment Manufacturing Company, New York, N. Y. Announcement was also made of the establishment of the Electronics Division of Otis Elevator Company, of which Morton B. Kahn, president of Transmitter Equipment Manufacturing Company, will be manager. The Electronics Division will be located at 35 Ryerson Street, Brooklyn, N. Y. Transmitter Equipment Manufacturing Company will remain in operation to complete its existing contracts.

Federal Telecommunication Laboratories Merger. Federal Telecommunication Laboratories, Inc., has been merged into its parent corporation, International Telephone and Telegraph Corporation. As a result of the merger, the business and activities of the Laboratories will be carried on and conducted under the name Federal Telecommunication Laboratories, a division of International Telephone and Telegraph Corporation.

Hagerty Elected RCA Director. Harry C. Hagerty has been elected a director of the Radio Corporation of America. Mr. Hagerty, financial vice-president and a director of the Metropolitan Life Insurance Company, fills a vacancy on the RCA Board left by the resignation of Lewis L. Strauss, following his appointment as chairman of the Atomic Energy Commission. Mr. Strauss also resigned as a director of the National Broadcasting Company and that directorship will be filled by William E. Robinson, publisher and executive vice-president of the New York *Herald Tribune*, who is a director of RCA.

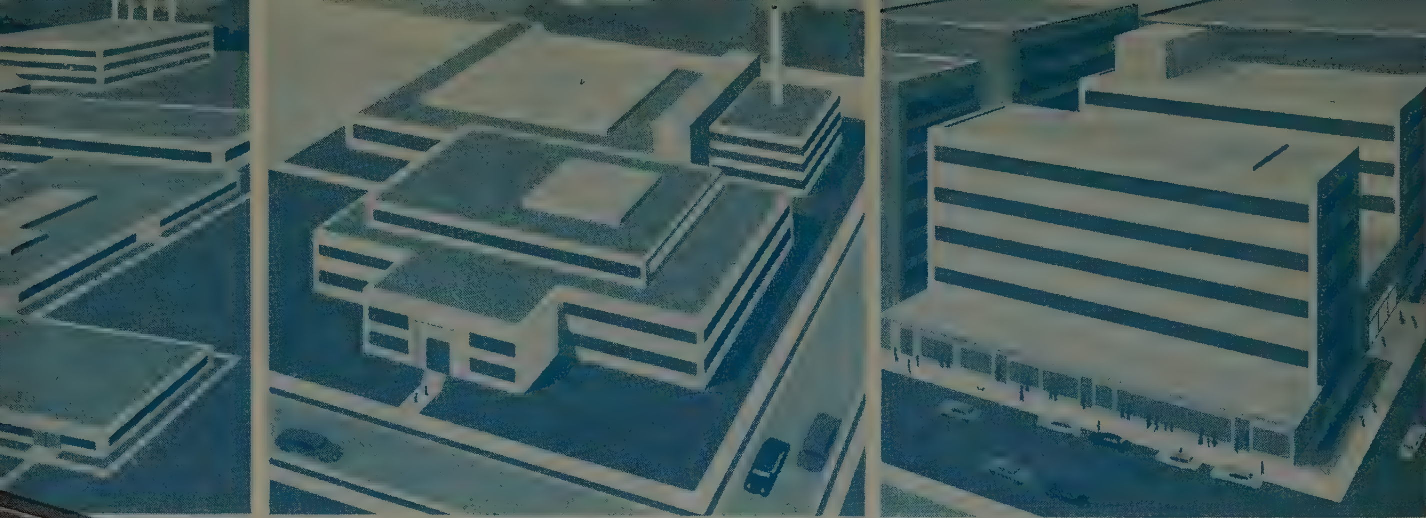
Minnesota Mining and Manufacturing Purchases Company. Purchase of Irvington Varnish and Insulator Company, Irvington, N. J., by Minnesota Mining and Manufacturing Company was announced recently. Irvington has become a division of Minnesota Mining and Manufacturing. No changes will be made in Irvington's operating policies or management.

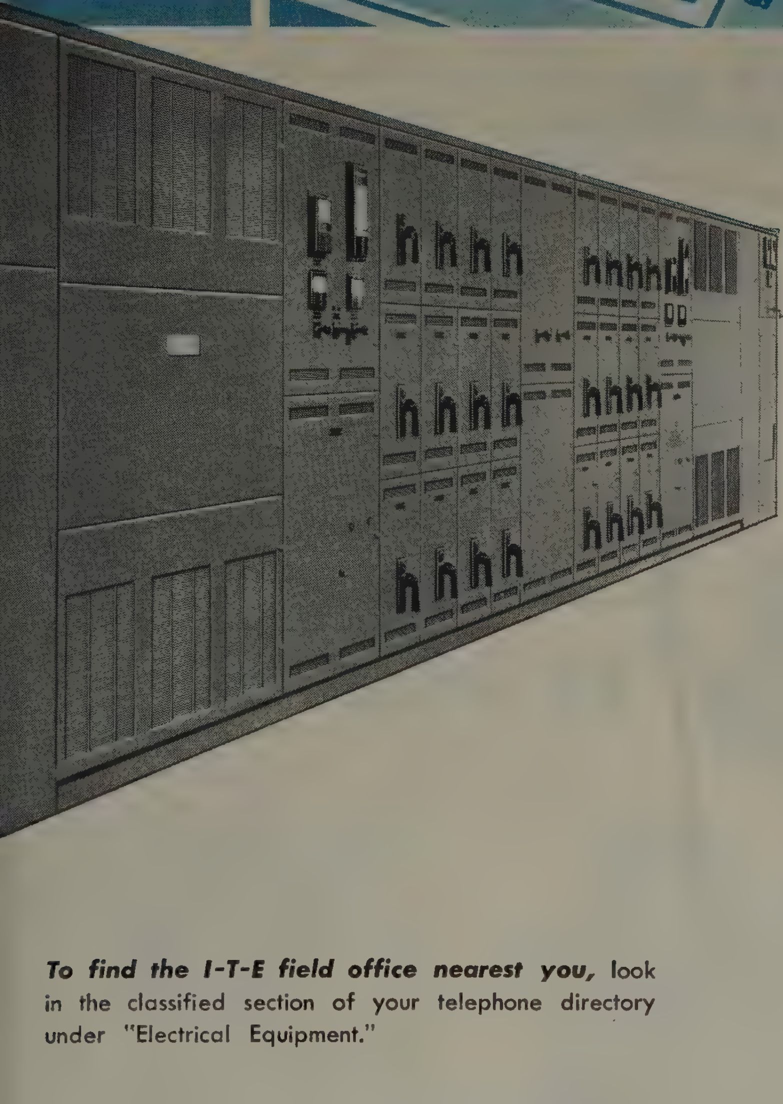
General Electric to Construct New Plant. Plans to construct a modern manufacturing plant at Jonesboro, Ark., which will employ approximately 300 people, were announced recently. The plant is to be part of the company's Specialty Fractional Horsepower Motor Department and will manufacture small blower and fan motors for refrigerators, air conditioners, and other equipment.

Du Mont to Sell Dage Equipment. The Television Transmitter Division of Allen B. Du Mont Laboratories, Inc., will sell the broadcast television cameras and camera equipment of Dage Electronics Corporation. Availability of the Dage equipment through Du Mont will provide an extra service to station owners by supplementing Du Mont's line of high-quality image orthicon camera units with lightweight, ultraportable, inexpensive Dage units which employ vidicon tubes.

Willys to Build Television Transmitters. The Electronics Division of Willys Motors, Inc., is entering the television transmitter business. Willys proposes to supply a complete television package consisting of 1,000-watt transmitters operating from 450 to 900 megacycles, camera, projector, console, panel, and so on, for holders of television licenses in areas of 50,000 population or less where high-powered television signals are not received. A prototype transmitter, now in production, is expected to be ready for submission to the Federal Communications Commission for approval in about 2 months. The

(*Continued on page 24A*)





I-T-E offers a complete line of quality unit substation equipment

Through the years, I-T-E has led in the development and manufacture of quality circuit breakers and switchgear. Similarly, since the inception of the Unit Substation, and its use in modern distribution systems, I-T-E has continued to hold this same envied position. Today, I-T-E supplies a full line of quality Unit Substations, in types and sizes to fit every application.

As an *extra service*—to help users make the wisest investment possible—I-T-E furnishes engineering assistance in the selection and application of equipment, preparation of specifications, and co-ordination of all job requirements. There are I-T-E Application Engineers in every major industrial area for this purpose.

To find the I-T-E field office nearest you, look in the classified section of your telephone directory under "Electrical Equipment."

I-T-E Circuit Breaker Co., 19th and Hamilton Sts.
Philadelphia 30, Pa.

UNIT SUBSTATIONS

(*Continued from page 20A*)

company is also working to develop a transmitter that meets the special requirements of educational television systems, but has no intention of building radio transmission equipment.

Reliance Staff Additions. Addition of three engineers to the Cleveland, Ohio, Buffalo, N. Y., and Detroit, Mich., district sales offices of the Reliance Electric and Engineering Company has been announced. Donald L. Peterson has been assigned to the Cleveland office; David H. Rush to the Buffalo office; and John E. Harger to the Detroit office.

NEW PRODUCTS • •

Voltage-Regulator Switch. A new bypass switch for use with voltage regulators on 7.5-, 15-, and 23-kv distribution circuits is available from the Westinghouse Electric Corporation. In isolating or reinserting a voltage regulator, this switch does the work of three. The lineman opens the switch with a hookstick; the switch contacts operate in sequence, first shunting the regulator and then disconnecting the regulator from the line. The switch has a load current rating of 600 amperes and will handle short-circuit currents up to 20,000 amperes. For further information write Westinghouse Electric Corporation, Box 2099, Pittsburgh, Pa.

Air-Line Microvolt Signal Generator. An air-line microvolt signal generator is announced as the only signal generator of its kind to provide continuous coverage from 125 kc to 165 megacycles on fundamentals. The Hickok model *292XAL*, the generator is built to meet exacting requirements. It provides complete coverage of the aircraft band including all the necessary intermediate frequencies and covers all radio frequencies with calibrated output. It can be modulated externally from 15 to 10,000 cycles per second and measures both input and output of units under test. The generator maintains dependable and accurate frequency calibration, is free of wave distortion, and has no spurious signals in the output system. For complete information write to H. D. Johnson, Hickok Electrical Instrument Company, 10515 Dupont Avenue, Cleveland 8, Ohio.

Corona Testing Equipment. Corona test sets for insulation testing have been developed by the James G. Biddle Company. The sets consist of a control unit, a detector unit, and a high-voltage corona-free testing transformer which incorporates means for picking up corona signals from the equipment under test. In operation, the equipment to be tested is connected

(*Continued on page 30A*)

Field Proof-

Here's the Tap-Changing-Under-Load Mechanism That Has Given 20 Years of Unequalled Performance

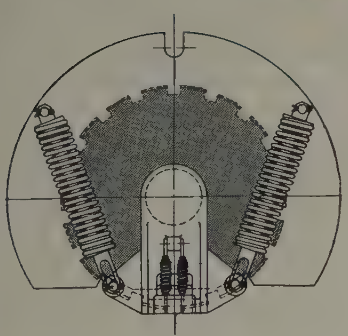
Field-proved — and unsurpassed in twenty years — that's the story behind Allis-Chalmers famous *Quick-Break* tap-changing mechanism. No other tap changer on the market gives you its combination of ruggedness, accuracy, and simplicity — features that add up to practically trouble-free operation.

Laboratory-proved — tests show that the *Quick-Break* mechanism will withstand 5 million operations — equivalent to over one hundred years of normal service. The *Quick-Break* mechanism was designed to operate under the most difficult conditions. After twenty years of field operation, it is still the simplest, most efficient means of changing taps under load.

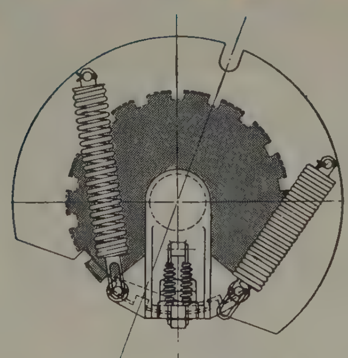
Get More Facts. If you don't have all the facts already, it will pay you to get more details by contacting your nearby Allis-Chalmers office or writing Allis-Chalmers, Milwaukee 1, Wisconsin.

A-4127

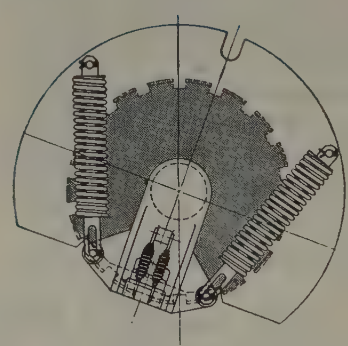
How It Works



1 Dial switch operates on the balanced spring principle. Components include outer moving segment, inner stationary index plate, and powerful springs for fast drive snubbing action.



2 Start: driving motor rotates outer segment but latch on crank arm holds tap switch in position. Heavy-duty springs store energy to produce quick start and stop of switch.



3 Finish: cam on segment lifts latch. Released spring tension rotates switch swiftly to next operating position. Latch locks switch and places mechanism in position for next change.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

(*Continued from page 24A*)

to the high-voltage terminal of the testing transformer and 60-cycle test voltage is increased until corona indication appears on the cathode-ray tube in the detector unit. The rms equivalent of peak voltage is read then from the adjacent peak voltmeter. Model *1* is rated 0.75 kva, 20 kv, for continuous duty or 1.5 kva for intermittent duty. It is available also with a larger control unit with a rating of 2 kva for continuous and 5 kva for intermittent duty. Model *2* is rated up to 10 kva, 35 kv, for continuous or 20 kv for intermittent duty. Information is available on request to the James G. Biddle Company, 1316 Arch Street, Philadelphia, Pa.

Rectifier for Magnetic Devices. A small, compact, inexpensive, single-phase bridge rectifier, type *D-3575*, has been developed by International Rectifier Corporation, 1521 East Grand Avenue, El Segundo, Calif., for the operation of magnetic devices such as relays, solenoids, and electric counters. The unit is designed for use directly for 117-volt a-c systems and is rated to deliver an output of 9 watts at 90 volts direct current continuous duty. With the addition of a 3-microfarad or larger filter capacitor, the rectifier will deliver 117 volts direct current for operation of devices normally designed for this voltage. The magnetic device can be used in conjunction with this rectifier to operate directly from the 117-volt a-c line. The use of type *D-3575* selenium rectifier reduces the iron core losses and the undesirable hum common with a-c magnetic devices. Shock and vibration characteristics are improved and the burning of delicate contacts is eliminated.

Automatic Checkers. A family of high-speed high-reliability automatic checkers that detect and locate wiring discrepancies and reduce test time to an absolute minimum has been developed by Federal Telephone and Radio Corporation. Through the use of this device 44 complex circuits can be checked thoroughly in less than 3 minutes. The tester automatically checks circuits for transposition, continuity, ground, and proper value of resistance. In case of trouble it clearly indicates the location of the fault. Connections between the circuit checker and the units to be tested are made through cables that can be plugged into the various tube sockets and receptacles available on the tested units thereby permitting rapid connect and disconnect operations. The standard circuit checkers can test up to 100 circuits automatically. Further information can be obtained from Component Sales Department, Federal Telephone and Radio Corporation, 100 Kingsland Road, Clifton, N. J.

Voltage Regulator. Avion Instrument Corporation has announced the development of a new precision a-c regulator for 400-cycle supplies. Rms output voltage is adjustable, with regulation to 0.01 per cent up to half the rated load (50

(*Continued on page 42A*)

GLENMONT STATION of Niagara-Mohawk Power Corporation is designed to supply electrical energy for a wide area, including Rome, Utica, Troy, Amsterdam, Canajoharie, Schenectady and Albany itself. Located along the Hudson River, it is the last word in power generating efficiency. Total rated capacity, when completed, 320 m-w.

or new Albany station

When utility engineers consider cables for their station planning, they thoroughly investigate available cable constructions from the standpoint of reliability, handling qualities, and neatness of appearance after installation. This was the case when Niagara-Mohawk Power Corporation engineers studied conditions connected with two recent station installations. And they found that Rome cable met these specifications.

There are many miles of Rome cable in the new Glenmont Station of Niagara-Mohawk now nearing completion near Albany, N. Y. Rome cables were also used in their Dunkirk Station, completed in 1951.

Four 80 m-w units are involved at Glenmont with provisions for further additions. Nearly 110 miles of Rome control cable and over 41 miles of Rome power cable have been supplied for this station.

CONTROL CABLES

The control cables are insulated with RoLene (polyethylene) and jacketed with Rome Synthinol. RoLene is practically unaffected by water, dc electro-osmosis, and low temperatures. It resists most chemicals, oxidation and oils.

The tough protective sheath of Rome Synthinol provides exceptional resistance to moisture, corrosion, abrasion and flame. Its aging characteristics assure long life under severest operating conditions.

POWER CABLES

The power cables are insulated with RoZone and jacketed with RoPrene (Neoprene). A premium quality oil-base type of insulation, RoZone exceeds all requirements of ASTM specification D-574 assuring unquestioned dependability. It is resistant to corona action and aging. It shows high stability in water and possesses excellent electrical characteristics. As a further safeguard, every foot of power cable rated at 3000 volts and over is subjected to ionization testing as a standard manufacturing control. This test assures less maintenance problems.

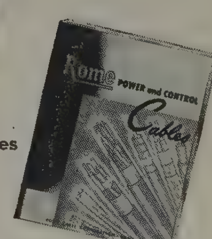
VERSATILITY COUNTS

All Rome thermoplastic station control cables are adaptable to installation requirements. They may be installed in ducts, trays, or on racks—or used in circuits combining all these installation methods. They are recommended for operating temperatures up to 75° C. Versatility is one of the reasons underlying the preference of utilities, consulting engineers and industrials for Rome power and control cables.

(Left) Rome station control cable with RoLene insulation and a Rome Synthinol sheath . . . designed for installation in ducts or in air.

(Right) Rome power cable with RoZone insulation and RoPrene sheath . . . designed for installation in ducts or in air.

Let us send you our latest catalog on Rome Power and Control Cables



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Name ....

Company ....

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(*Continued from page 30A*)

volt-amperes) and to 0.02 per cent up to the full rated load (100 volt-amperes). This regulation is maintained with allowable input voltage fluctuations of ±10 per cent about the adjusted output level, and frequency fluctuation of ±5 per cent. Recovery time from transients is less than 0.01 second. Developed harmonics are less than 1 per cent. Further information may be obtained from the manufacturer, Paramus, N. J.

Emergency A-C Power Supplies. Up to 250 watts of 110-volt a-c power can be obtained from 24- or 48-volt storage batteries with Lenkurt *5060A* and *5070A* emergency a-c power supplies. Designed to meet a wide range of applications where a-c operated equipment at attended or unattended locations cannot be interrupted for even short intervals, these emergency power supplies are suitable for use with 3-channel carrier terminals, carrier repeaters, small radio stations, or similar equipment. Automatic transfer to the emergency source is completed within 0.5 second after failure of the normal a-c power. The emergency supply is equipped so the load can be returned to the normal source either automatically or manually when power is restored. Complete specifications may be obtained from Lenkurt Electric Company, 1105 County Road, San Carlos, Calif.

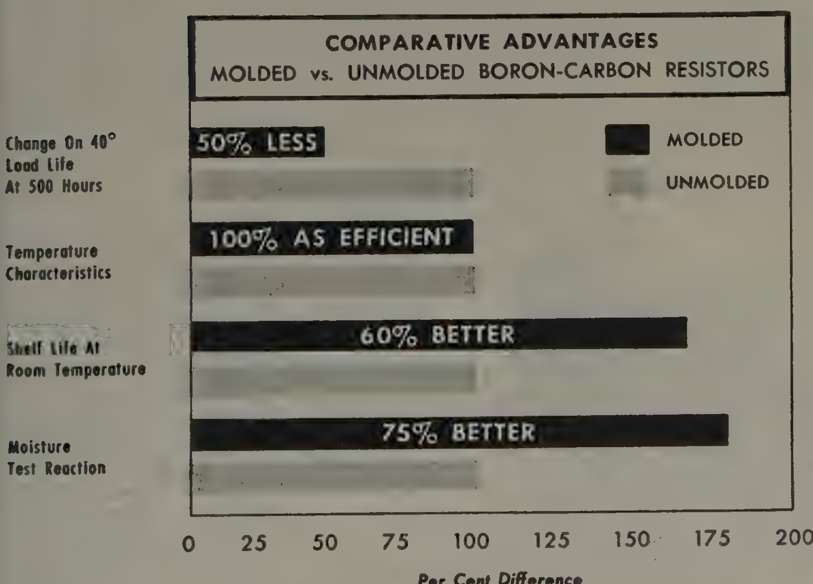
Low-Melting Silver Alloy. Newly created EutecRod *1602,* which features flowing characteristics on difficult to braze alloys and steels, has been announced by Eutectic Welding Alloys Corporation. EutecRod *1602* flows smoothly and easily at elevated temperatures, permitting the use of silver brazing-type joints on all tough to bond alloys which have refractory oxides of chromium, vanadium, nickel, and so forth. The product also features the outstanding advantage of considerably lower heat input required for "T" and butt joints where a white solder-type alloy is desired on stainless steel. For further details write Department P, Eutectic Welding Alloys Corporation, 172d Street and Northern Boulevard, Flushing, N. Y.

Pilot Relay Unit. A differential converter unit incorporating a pilot relay transmitter that reduces air consumption to the minimum has been developed by the Minneapolis-Honeywell Regulator Company's Industrial Division. The new differential converter with the pilot relay transmitter uses only 1/6 as much air as the conventional nozzle-pressure transmitters. They are virtually unaffected by variations in the air supply. Highly responsive to changes in flow, the new relay permits control within close tolerances necessary to many industrial processes. The differential converter units have a high temperature rating, meter bodies can stand process fluid temperatures up to 350 degrees Fahrenheit, and the transmitter up to 225 degrees Fahrenheit.

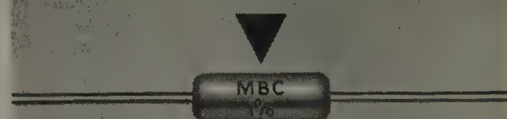
(*Continued on page 50A*)

NOW
a *molded* boron-carbon resistor

The inherent superiority of a boron-carbon resistor is now available with added advantages of a fully insulated unit. The IRC Type MBC ½ watt, 1% resistor offers significantly better characteristics plus protection against damage during assembly. Send coupon for detailed information.



Eliminates Possibility Of End-Cap Trouble



Eliminates Danger Of Mechanical Damage

Improves Electrical Characteristics

Costs No More Than IRC Unmolded Type With Protective Sleeve

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In Canada:
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INTERNATIONAL RESISTANCE COMPANY
411 N. Broad Street, Philadelphia 8, Pa.

Please send Technical Bulletin describing Type MBC resistors:

Name ....

Title ....

Company ....

Address ....

City .... State ....

(*Continued from page 42A*)

Ultrasensitive Polarized D-C Relay. The new Barber-Colman ultrasensitive d-c relay is hermetically sealed with either octal plug or solder terminals. Standard contact configuration is single pole, double throw, null seeking. Sensitivities of null-seeking types range from 50 microwatts to 100 milliwatts. The unit is ideal for balance detecting bridge circuits and as a plate current relay in electronic circuits. A current-generating-type photocell will provide sufficient power to operate the relay directly, eliminating costly amplifiers. Ultrasensitive polarized relays and sensitive relays are manufactured by the Barber-Colman Company, Rockford, Ill.

Ceramic Magnets. A newly developed magnetic material, known as Magnadur, contains no nickel, cobalt, tungsten, chromium, or other critical materials. The Magnadur magnets are made by a process of powder metallurgy from a mixture of barium and iron oxide, pressing or extruding the mixture in shape and sintering in furnaces at very high temperatures. The resultant product is a very hard, rather brittle black pottery-like substance with excellent permanent magnet qualities when magnetized. Magnadur has extremely high coercive force and unusually high resistance to demagnetization as well as excellent magnetic stability. Its high resistance permits the use of Magnadur magnets in the presence of high-frequency fields without undesirable losses. Complete technical data may be obtained in bulletin *FC-6000* which is available on letterhead request to the Ferroxcube Corporation of America, 321 Marshall Street, North Adams, Mass.

Sealed Power Connectors. A new series of sealed power connectors manufactured by Cannon Electric to the Signal Corps specifications for power units of audio equipment is available. Signal Corps identification of these connectors range from *U-112/U* to *U-117/U*. All plugs are the angle 90-degree type with wing blade handle which operates a screw for easy engagement and disengagement under conditions in which operator's hand would be gloved. Receptacles are round, with a lock ring for panel mounting. Contact arrangements are 4 number 16, 12 number 16, and 29 number 16 contacts having 2,500-volt a-c rms flashover values. For further information write Cannon Electric Catalogue Department, 420 West Avenue 33, Los Angeles 31, Calif., and ask for *2E-1* bulletin.

Resistors for Printed Wiring. The Electronic Components Division of the Stackpole Carbon Company, St. Marys, Pa., has announced that its standard 1/2-watt fixed composition resistors are available now with specially formed and trimmed leads. This feature facilitates the handling of resistors when assembling components on the standard 0.062-inch printed wiring base. The hot tin dipped leads are cut and formed by Stackpole for

(*Continued on page 52A*)

(*Continued from page 50A*)

a tight fit and extend through the printed circuit base just far enough for easy soldering. Resistors snap into place. No additional operations need be made for proper assembly. Samples and full details will be sent to quantity users on letterhead request to the manufacturer.

Electronic Predetermining Counter. Computer Research Corporation has developed an electronic predetermining counter capable of counting up to 1,800,000 cycles per minute without the use of vacuum tubes. The unit incorporates true ring elements in an improved ferroresonant circuit which is not sensitive to heat. This feature, plus its immunity to shock and vibration, make it an extremely reliable device. It can start or stop counting on any count, control operations by the use of frequency division, or emit an output pulse at any predetermined count, for use in driving external devices. The output pulse is adaptable also for direct use with magnetic amplifiers for controlling large amounts of power without vacuum tubes or switches. Write for additional information to Component Sales, Computer Research Corporation, 3348 West El Segundo Boulevard, Hawthorne, Calif.

TRADE LITERATURE

Power Supplies and Electronic Instruments. Beta Electric Corporation has announced the release of a 32-page general catalogue containing complete specifications on the Beta line of power supplies and electronic instruments. Tabular listings of the 120 standard designs of low-, high-, and ultrahigh-voltage power supplies show all vital specifications and characteristics. In addition, detailed descriptions are given for each type of supply. Beta oscilloscopes, electronic rheostats, and electronic micrometers are covered also. Copies may be obtained by writing Beta Electric Corporation, 333 East 103d Street, New York 29, N. Y.

Electric Heating Units. The Watlow Electric Manufacturing Company, St. Louis, Mo., has released the 1953 edition of the company's electric heating unit catalogue. Tab-indexed for quick reference, the catalogue contains descriptive matter, specifications, and illustrations on the company's line of strip, cylindrical, ring, cartridge, tubular, and immersion heaters, package-sealing devices, hot plates, thermostats, rheostats, switches, contactors, capacitors, insulators, and leads. A special section is devoted to useful engineering data. Included are such topics as methods of transmitting heat; how to determine wattage requirements; capacities; specific heat tables for various solid, liquid, gas, and vapor substances; heat losses; and energy required for heating air and water.

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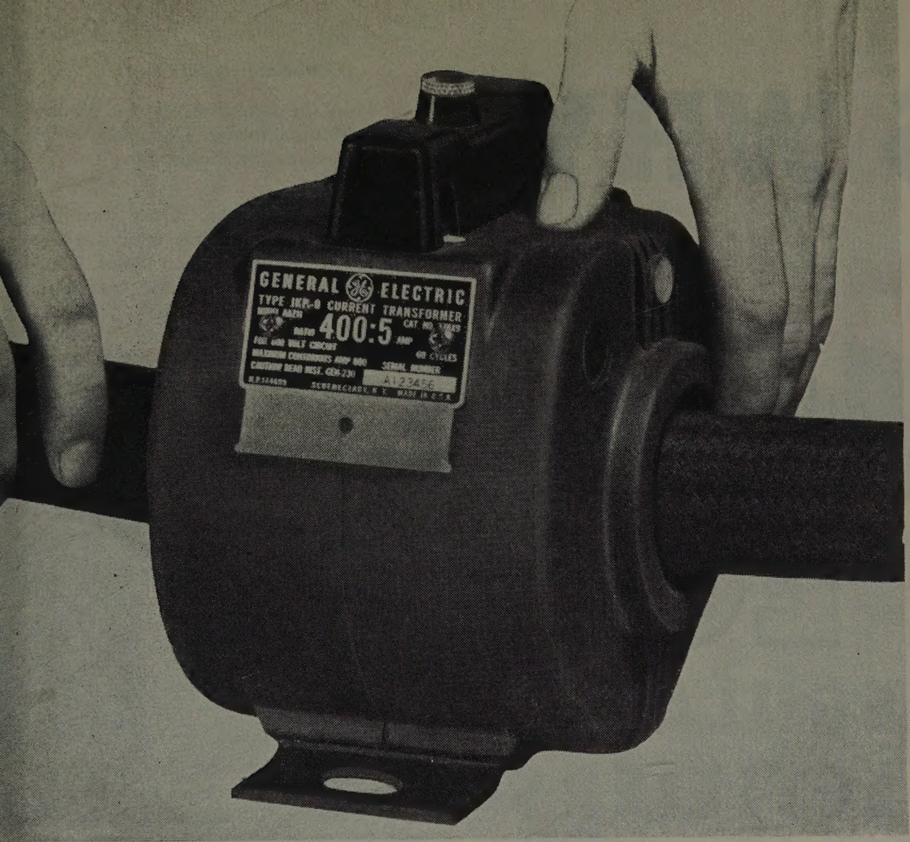


BUTYL-MOLDED, OPEN-WINDOW DESIGN Gives JKP-0 indoor-outdoor versatility. Cut your stock and inventory costs with JKP-0 indoor and outdoor 600 volt applications.

4 in 1

NEW G-E CURRENT TRANSFORMER REPLACES 4 STANDARD MODELS

An outstanding advantage of the Type JKP-0, 600-volt butyl-molded current transformer is its versatility —it easily replaces 4 different types. Here are four ways the JKP-0 saves you money:

1. STOCKING COSTS REDUCED. Standardizing on the JKP-0 cuts costs by reducing stock requirements, simplifying ordering.

2. MAINTENANCE IS REDUCED. JKP-0 transformers will not corrode, breakage is reduced, no painting is needed—JKP-0 is butyl-molded.

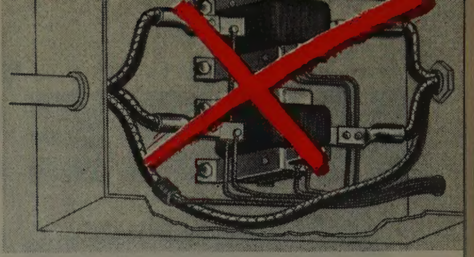
3. INSTALLATION COSTS CUT. The JKP-0 does not require elaborate arrangements of crossarms, hanger connections, etc.—and the amount of wiring is reduced.

4. LOWER INITIAL COST. This versatile transformer sells for less than most of the conventional types it replaces.

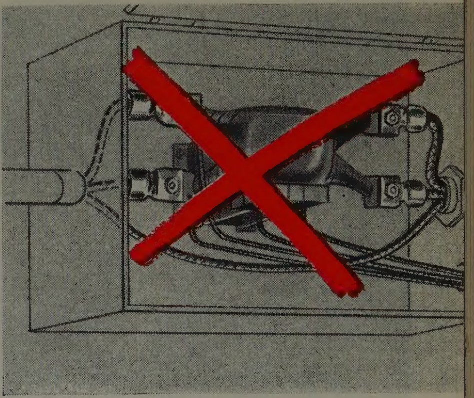
Write or call your nearest G-E Apparatus Sales Office, or authorized agent or distributor. Ask for Bulletin GEA-5874. General Electric Company, Schenectady 5, New York. 604-38

You can put your confidence in—

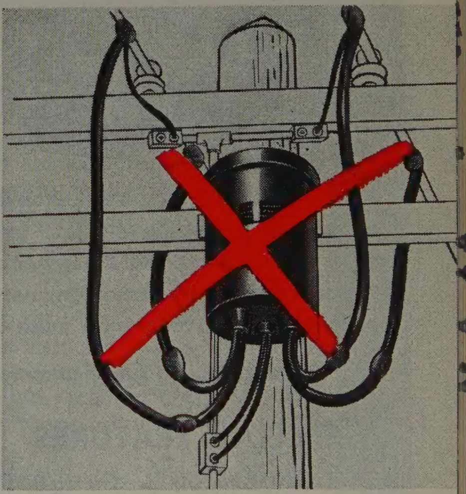
GENERAL ELECTRIC



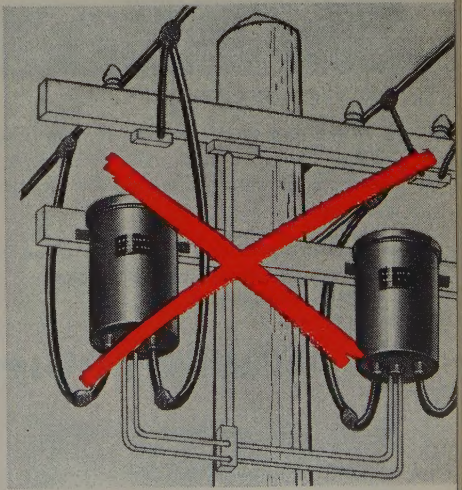
REPLACING INDOOR JL-1 (or newer JKR-0) with the JKP-0 means simplified wiring, fewer connectors—cut costs!



CARRY ONE MODEL in stock instead of four! Above: JKR-1, another transformer easily replaced by the new JKP-0.



FOR OUTDOOR JOBS the JKP-0 eliminates costly crossarms and connectors demanded by conventional Type JKB-1.



ANOTHER OPPORTUNITY to standardize is realized when butyl-molded JKP-0 replaces JKB-2 outdoor current transformer.

(*Continued from page 52A*)

For a copy of the catalogue, address Watlow Electric Manufacturing Company, 1367 Ferguson Avenue, St. Louis, Mo.

Arc-Welding Machines. Over 20 different models of arc-welding machines are described in Air Reduction Sales Company's arc-welding machines catalogue. A-c, d-c, and inert-gas models are illustrated with complete descriptions covering specifications, features, and electrical data. The 44-page catalogue also includes sections on the accessories and electrodes required to perform a particular arc-welding job. Included in the line of arc welders are d-c motor-generator and engine-driven sets, d-c selenium rectifiers, a-c machines specifically developed for Heliwelding applications, and a-c transformer welders. Also discussed are various types of running gear, foot controls, and an automatic arc-welding head. Copies should be requested from Air Reduction Sales Company, 60 East 42d Street, New York 17, N. Y.

D-C Motors and Generators. The Louis Allis Company has released a 16-page bulletin covering its line of d-c motors, 1/2 to 300 horsepower, and d-c generators, 3/4 to 250 kw. The bulletin is illustrated and photographs and cutaway drawings show details of d-c mechanical construction, available d-c motor enclosures for different operating conditions, d-c motor applications, and several special d-c designs. The bulletin also includes a section on motor-generator sets for converting alternating current to direct current in industrial service. Copies of bulletin *1450* may be obtained from any Louis Allis district sales office or distributor or by writing the Louis Allis Company, Milwaukee 7, Wis.

Electrical Insulation Price Catalogue. A 140-page catalogue including information on standard put-ups, terms, and aggregation policies is available from Insulation Manufacturers Corporation. The catalogue includes prices on such material as cords and twines, untreated woven tapes, sleevings and tubings, paper and paper products, slot wedges, reinforced or laminated plastics, vulcanized fiber, plastic or resinous films, pressure-sensitive tapes, varnishes and compounds, mica products, varnished fabrics and paper combinations, and miscellaneous materials. Copies of the catalogue are available without charge by writing Publications Department, Insulation Manufacturers Corporation, 565 West Washington Boulevard, Chicago 6, Ill.

Microwave Radio for Electrical Utilities. Application of new 2,000-megacycle microwave radio equipment to electrical utilities is described in a booklet available from the Westinghouse Electric Corporation. Features of *FR* microwave radio and *FJ* multiplexing equipment and their importance to the electrical utility industry are discussed. Points covered include

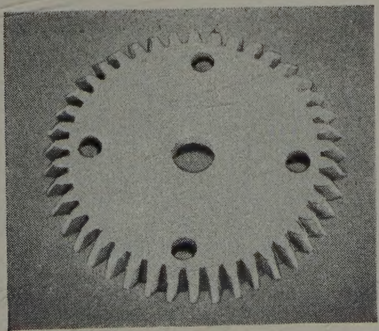
(*Continued on page 64A*)

# of Du Pont nylon plastic new fare collector

The Grant Electrofarer is a completely automatic fare-collection device . . . gives drivers an audible count and visible check of coin deposits. It can receive a single- or multiple-coin fare deposited in any combination of up to five coins and tokens, record the amount, then separate and drop each coin into its change carrier. It eliminates all driver fare handling except making change . . . contributes to safer, faster service.

The device incorporates 54 different parts of Du Pont nylon plastic. These parts (a few are illustrated) show how the engineering properties of Du Pont nylon can contribute to better product performance, often at less cost.

The parts were molded from Du Pont nylon by The Danielson Mfg. Co., Danielson, Conn., for Grant Money Meters Co., Providence, R. I.



NYLON GEARS can *operate continuously to 250°F.* . . . are readily molded in one operation . . . cut costs.

Du Pont nylon parts can be economically mass-produced by injection molding . . . are light in weight . . . give better performance. Nylon molding powders are available in a number of compositions, each with different properties, for mechanical, electrical and other uses. For information, write: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., Room 2110 Du Pont Bldg., Wilmington, Delaware.

DU PONT

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BETTER THINGS FOR BETTER LIVING
... THROUGH CHEMISTRY

Polychemicals

DEPARTMENT

PLASTICS • CHEMICALS

(*Continued from page 60A*)

frequency division multiplexing, crystal frequency control, stand-by equipment, maintenance features, and many others. For a copy of this booklet, *B-5850*, write Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

Carbon and Graphite Products. Standard and special carbon and graphite components and materials for chemical, electrical, and mechanical applications are described in catalogue *40A*, available from the Stackpole Carbon Company, St. Marys, Pa. The 44-page catalogue contains data on carbon and graphite as applied to electric contacts, bearing materials, seal rings, rail bonding molds, and many others. There is considerable engineering information on the physical and electrical properties of carbon and graphite as compared with metals and other refractory materials. Copies of Carbon Specialties Catalogue *40A* are available on letterhead request to Stackpole.

Photorecording From Cathode-Ray Tubes. "Techniques of Photorecording from Cathode-Ray Tubes" is a complete review of the problems and associated solutions encountered in photographing cathode-ray patterns. It is a 36-page manual offered by Technical Sales Department, Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Avenue, Clifton, N. J. The manual is illustrated with actual photorecordings, scales, graphs, and diagrammatic sketches. In addition to technique information, the manual contains complete descriptions and specifications of the Du Mont line of photorecording equipment. The manual is offered to qualified personnel requesting copies on business letterheads.

Control Systems Bulletin. A bulletin on 720-cycle control systems for off-peak control of water-heating loads has been announced by the General Electric Company, Schenectady, N. Y. The 28-page bulletin, designated *GEC-931*, contains information on station equipment, coupling equipment, and load switches, the three major components of the control systems. The bulletin lists the features and advantages of the equipment, including load switches, station equipment, load-control units, converters, couplings, capacitor reactors, and test equipment.

Power Oil Circuit Breakers. Construction features, ratings, dimensions, and weights of Allis-Chalmers power oil circuit breakers, types *OZ-15-100*, *OZ-15-250*, and *OZ-23-250*, are given in a new bulletin. The type *OZ* power oil circuit breaker is designed for outdoor distribution service where safe, reliable operation is a necessity. It is available with automatic reclosing relay equipment mounted on the side in a weatherproof cabinet. Copies of the bulletin, *71B7946*, are available on request from Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.